

BEIJING SENDIG TECHNOLOGY, LTD.

USER'S MANUAL

For the

SENDIG-903

A Portable

Microprocessor-Based

Vibration Data collector

On-site Balancer

Spectrum Analyzer

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THE SENDIG-903 USER'S MANUAL

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1. INTRODUCTION

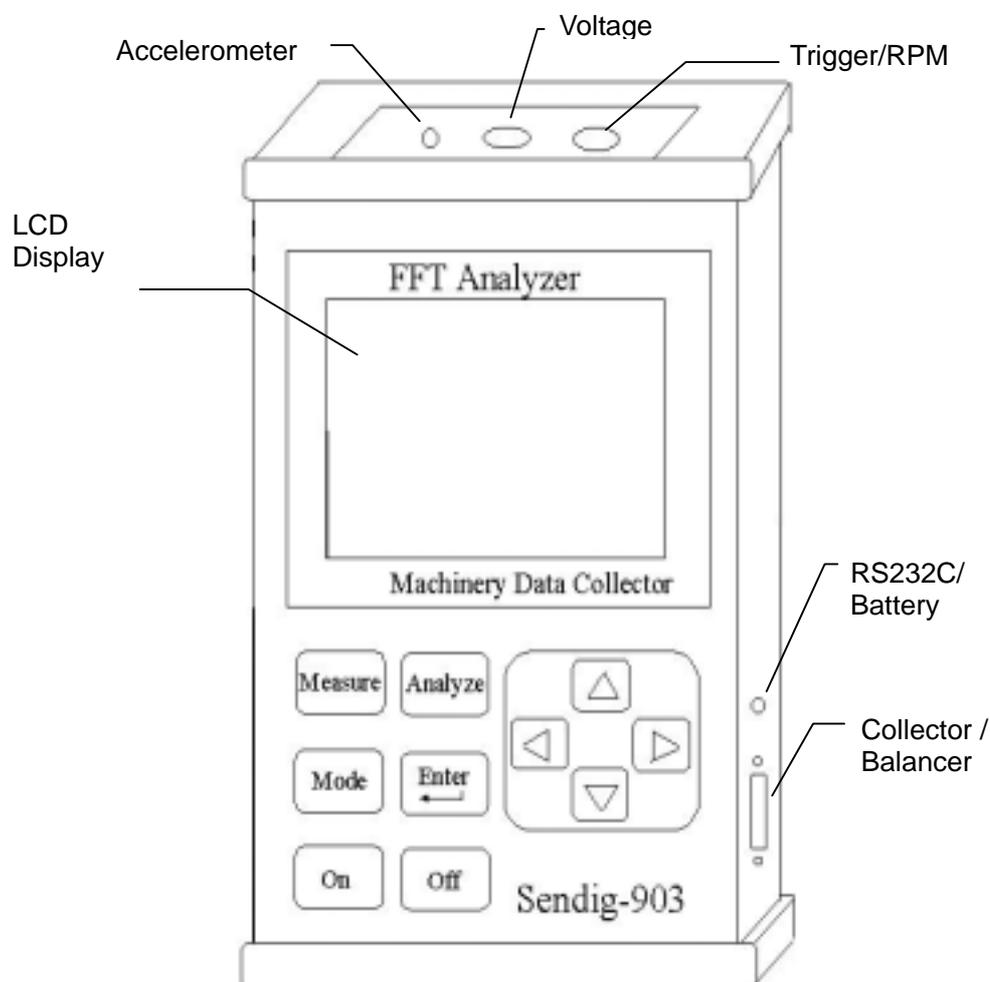


Figure 1.SENDIG-903 Panel and plugs

The SENDIG-903 is a state-of-the-art computerized instrument. It is an advanced machinery analyzer specially designed for maintenance and diagnosis of mechanical equipment. Integration of the functions of data collector, on-site balancer and dynamic spectrum analyzer makes it be able to do on-site FFT spectrum analysis and waveform display, collect full featured data for predictive maintenance, measure vibration displacement, velocity, acceleration and acceleration envelope with a single transducer. It has an optional balancing module for 1-plane and 2-planes rotor balancing with influence coefficient method, and it is also featured with spectrum comparison and trend analysis, various spectrum analysis, waveform analysis, time-domain diagnosis, bearing and gear box diagnosis with the PC software support. It has three main functions:

- Analyze and diagnose the faults of mechanical devices (rotor, bearing, gearbox, induction-motor, etc) on the spot.
- Collect and store information that corresponds to conditions of device. This information can be sent to computer to establish the maintenance database

- and make elaborate analyses and trend analyses.
- Measure vibration phases and calculate imbalance mass and location.

This instrument was designed to be “user friendly”, allowing the majority of users to operate the unit even without reading the User's Manual. The unit contains one keypad and one LCD. The keypad has ten keys: <Measure>, <Mode>, <Analyses>, <Enter>, <On>, <Off>, four cursor keys <↑>, <↓>, <←>, <→>. Users can do all operation with these keys.

The SENDIG-903 operates in two different triggering modes, the Free-Shot Mode and the Ext-Trig Mode. In the Free-Shot Mode, the unit continuously monitors its inputs at once. In the Ext-Trig Mode, measurement is triggered by a TTL impulse in the ‘Trigger/RPM’ socket.

The LCD asks the operator for input and also displays the graphs and analytical results when required.

All of this, and more, make the SENDIG-903 one of fieldwork instruments essential for machinery condition monitoring and fault diagnosis.

2. BASIC OPERATION AND SET-UP

2.1.General

The SENDIG-903 is a user-friendly instrument capable of recording vibration information accurately. In the Free-Shot mode, you can measure ENVE, ACC, VEL and DIS (The sensor connected in the “Accelerometer” socket) or VOL (The sensor connected in the “Voltage” socket) and display new measured and old data comparatively. Then the unit displays the conclusion according to the parameters set in the “AlmWv-Mode”.

In the Ext-Trig mode, the unit must have a trigger impulse signal connected in the “Trigger/RPM” socket, and the vibration signal is recorded only when the trigger impulse signal appears. Different from the Free-shot, user can get position-related information. Furthermore, you can measure rotate speed and make dynamic balance on the spot when the trigger is a photoelectric sensor.

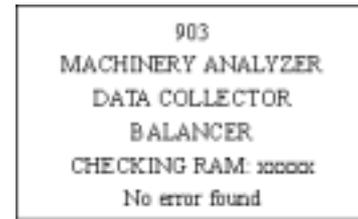
In either mode, the unit will operate about eight hours after full charged.

2.2.Setting up the SENDIG-903

Proceed as follows when using your SENDIG-903:

1. Check that the sensor is properly connected in the “Accelerometer” socket or “Voltage” socket. Usually, user uses charge-output-type acceleration transducer so plugs the cable into the socket marked “Accelerometer”.
2. Check that the trigger or photoelectric sensor is properly connected in the “Trigger/RPM” socket. (In Ext-Trig mode, measure rotate speed or make dynamic balance)
3. Install and fasten the sensor to the measured object.

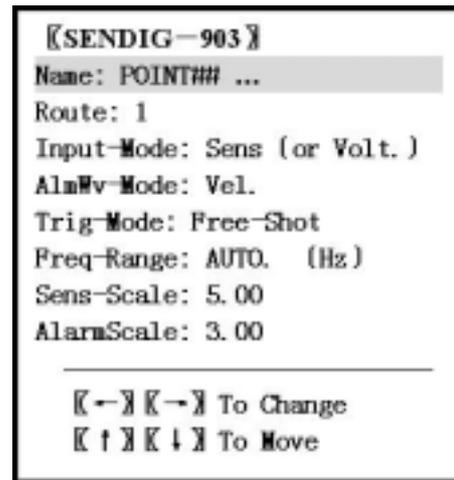
4. Install the trigger or photoelectric sensor correctly if you select the Ext-Trig mode.
5. Press the <On> key down and keep two seconds. The LCD will display the following:



- Notes:
1. If the LCD has no display, press the <Off> key and try again.
 2. To make dynamic balance, please press the red button at the right-hand side to bottom before pressing <On> key.
 3. If error found during ram checking, contact the manufacturer.

Soon, it enters into the measure menu. You can then start your operation.

- NOTES:**
1. If it is the first time to be used or not to be used long-term, charge the collector battery and format memory before operation. Charging should last for six hours at least. The method of formatting memory refers to the section 4.
 2. SENDIG-903 will switch the power off automatically if there is no any operation in about forty seconds. If it can't (such as measuring rotate speed), you can switch the power off by pressing <Off> key.



3. USING THE 'MEASURE' MENU

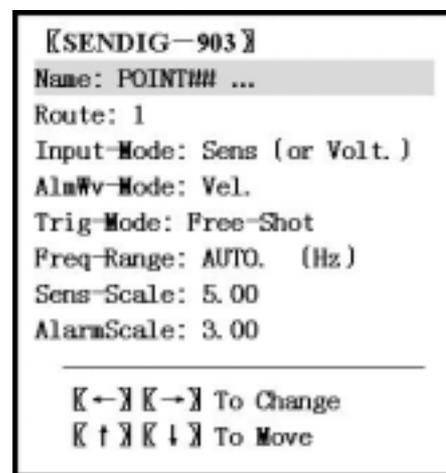
The function of the 'measure' menu is to help user observe and modify the measuring parameters. It is very important to confirm all the parameters in the menu before using SENDIG-903 to collect data. There are two ways to do this:

- A. Set up the collector by computer. Each parameter saved in the computer parameter database can be transmitted to the collector automatically. Then find out the measuring point name, press the <Enter> key, SENDIG-903 can collect and store data automatically.

NOTE: Please refer to the section 4 to save waveform.

- B. Without setting up collector by computer, you should set up the parameters in the 'measure' menu to get proper and reliable data. Press the <On> key down and keep two seconds. The LCD displays the measure menu. (Refer to the section 2.2)

At the bottom of the screen, there are two rows of notices called "help information" that changing with the location of the cursor. When the cursor is on the



last two items, the help information is:

```

[←] [→] To Adjust
[↑] [↓] To Move

```

When the cursor is on the other items, the help information is:

```

[←] [→] To Change
[↑] [↓] To Move

```

3.1. How to set up the measure point name (point ID)

Measure point name: (POINT0—269). Just after formatting the memory, the content of display is as followings:

```

[SENDIG-903]
Name: POINT## ...
Route: 1
Input-Mode: Sens (or Volt.)
AlmWv-Mode: Vel.
Trig-Mode: Free-Shot
Freq-Range: AUTO. (Hz)
Sens-Scale: 5.00
AlarmScale: 3.00
-----
[←] [→] To Change
[↑] [↓] To Move

```

The point name can also be inputted from computer. There is a space of sixteen-character for the input.

Route: (1—270). It indicates the sequence of measuring. <↑>, <↓> or <←>, <→>

If you want to change the point name, move the cursor to the Name line with <↑> or <↓> key, then find out the specific point name with <←> or <→> key.

3.2. How to set up the Input-Mode

Input-Mode includes two modes: Sens. (=sensor) or Volt. (=Voltage). The method of changing is as followings:

Move the cursor to the Input-Mode with <↑> or <↓> key, and then change the mode with <←> or <→> key.

```

[SENDIG-903]
Name: POINT## ...
Route: 1
Input-Mode: Sens (or Volt.)
AlmWv-Mode: Vel.
Trig-Mode: Free-Shot
Freq-Range: AUTO. (Hz)
Sens-Scale: 5.00
AlarmScale: 3.00
-----
[←] [→] To Change
[↑] [↓] To Move

```

We usually use the acceleration transducer, so adjust the Input-Mode to “Sens.” and link the sensor cables with the “Accelerometer” socket. When you are measuring with voltage signal, adjust the Input-Mode to “Voltage” with <←> or <→> key, link the signal with the “Voltage” socket and then measure it.

NOTE: If the Input-Mode is wrong, collected data will be incorrect.

3.3. How to set up the AlmWv-Mode

AlmWv-Mode decides which parameter to be used for alarm, which parameter's waveform to be saved and which parameter for FFT spectrum analysis. The method of setting up AlmWv-Mode is to move the cursor to the AlmWv-Mode with <↑> or <↓> key, and then adjust it with <←> or <→> key.

```

[SENDIG-903]
Name: POINT## ...
Route: 1
Input-Mode: Sens (or Volt.)
AlmWv-Mode: Vel.
Trig-Mode: Free-Shot
Freq-Range: AUTO. (Hz)
Sens-Scale: 5.00
AlarmScale: 3.00
-----
[←] [→] To Change
[↑] [↓] To Move

```

The meaning of each parameter is as followings:

DIS (Displace) ----- Peak-to-peak value, the maximum vibrating distance between the positive amplitude and the negative one of the vibration. DIS is usually used on the occasion where the gap of the machine parts is critical. Its unit is $\mu\text{m}= 1/1000 \text{ mm}$.

VEL (Velocity) ----- The root-mean-square (rms.) of velocity, often written as V_{rms} . It is usually used as the evaluation of machine vibrating. Its unit is mm/s .

ACC (Acceleration) ----- The peak value of acceleration, often written as A_p . SENDIG-903 adopts equivalent peak value, which equals to the value of root-mean-square acceleration (A_{rms}) multiplying 1.414. Its unit is m/s^2 .

ENVE (Acceleration Envelope) ----- The RMS of the envelope signal of high frequency acceleration after filtering off low frequency ($<1\text{kHz}$). Its unit is m/s^2 .

VOL (Voltage) ----- VOL adopted when using other sensors that output voltage signals. Its unit is V.

NOTE: AlmWv-Mode is limited by the Input-Mode.

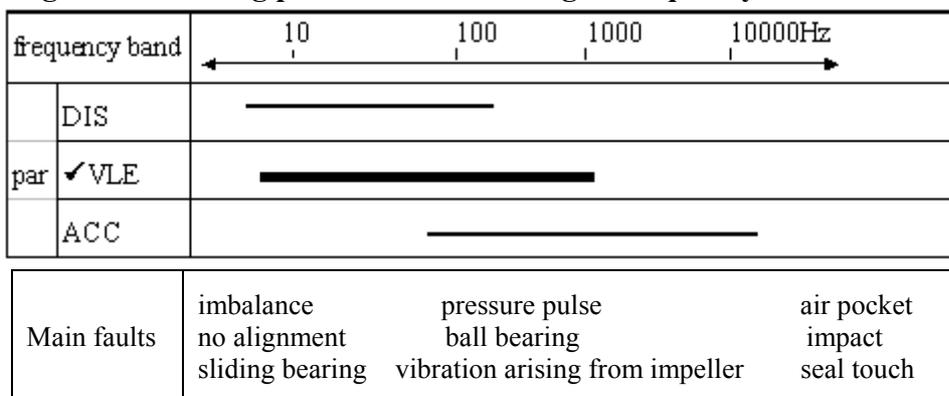
When the Input-Mode is Sens, there are four parameters to be selected: DIS, VEL, ACC, and ENVE. But When the Input-Mode is Volt, the only parameter is VOL, and outcome is as followings:

- V_p : peak value of voltage.
- V_{rms} : root-mean-square value of voltage.
- V_{p-p} : peak-to-peak value of voltage.

NEW data	OLD data
VOL: /	V_p
VOL: /	V_{rms}
VOL: /	V_{p-p}

When selecting measure parameters, you must think over the features of the measured device, frequency range of each parameter, and its sensibility to different faults and so on. The principle of selection is to offer the maximal information and easy-to-operate.

Figure 2. Selecting parameters according to frequency characteristic



Parameter	Type of abnormal	Examples
Displace	Problem arising from displacement or loose	Vibration of machine tools and revolving axis
Velocity	Problem arising from vibration energy and fatigue	Vibration of revolving machinery
Acceleration	Problem arising from impact, friction and etc.	Vibration of disfigurement of bearing and gearbox

3.4. How to set up the Trig-Mode

The Trig-Mode includes Free-Shot and Ext-Trig. Default selection is Free-Shot. When Trig-Mode is Ext-Trig, the unit must have a triggering signal. Otherwise, the unit will

wait to be triggered at all times.

The method of operation is as followings:

Move the cursor to the Trig-Mode with <↑> or <↓> key, then adjust it with <←> or <→> key.

NOTE: Normally, we select Free-Shot. Otherwise the collector will wait for triggering signal and it will not collect data without the signal.

```

【SENDIG-903】
Name: POINT## ...
Route: 1
Input-Mode: Sens (or Volt.)
Alm#v-Mode: Vel.
Trig-Mode: Free-Shot
Freq-Range: AUTO. (Hz)
Sens-Scale: 5.00
AlarmScale: 3.00

-----
【←】【→】 To Change
【↑】【↓】 To Move
  
```

3.5. How to set up the Freq-Range

Freq-Range indicates the frequency span of spectrum analysis. It has eight options including AUTO, 100, 200, 500, 1000, 2000, 5000, and 10000(Hz). When AUTO is selected, the frequency range of each parameter will be:

ENVE: 1000 (Hz)
 ACC: 10000 (Hz)
 VEL: 1000 (Hz)
 DIS: 500 (Hz)

Additionally, the other seven frequency ranges can also be selected. It is very important to define the frequency range because different machines have different rotate speeds. So good data can be gained only if correct Freq-Range is selected.

The method of modifying the Freq-Range: move the cursor to the Trig-Mode with <↑> or <↓> key, then adjust it with <←> or <→> key.

3.6. How to set up the Sens-Scale

Generally speaking, different sensors have different sensor scales. Before operating SENDIG-903, you must make sure the sensibility of the collector according with the scale of the sensor (0.01~100). Otherwise, the measuring is not precise.

The method of modifying is: Move the cursor to the Sens-Scale with <↑> or <↓> key, then adjust it with <←> or <→> key.

```

【SENDIG-903】
Name: POINT## ...
Route: 1
Input-Mode: Sens (or Volt.)
Alm#v-Mode: Vel.
Trig-Mode: Free-Shot
Freq-Range: AUTO. (Hz)
Sens-Scale: 5.00
AlarmScale: 3.00

-----
【←】【→】 To Change
【↑】【↓】 To Move
  
```

3.7. How to set up the Alarm-scale

Alarm-scale (0.01~999) is the coefficient between the alarm value and reference value of vibration.

The function of Alarm-scale is to alarm when the measuring value multiplied by Alarm-scale is larger than the reference value, then such conclusion as "Signal Too Strong" is drawn. (Refer to the section 3.8)

The method of modifying is: Move the cursor to the

```

【SENDIG-903】
Name: POINT## ...
Route: 1
Input-Mode: Sens (or Volt.)
Alm#v-Mode: Vel.
Trig-Mode: Free-Shot
Freq-Range: AUTO. (Hz)
Sens-Scale: 5.00
AlarmScale: 3.00

-----
【←】【→】 To Change
【↑】【↓】 To Move
  
```

Alarm-Scale with <↑> or <↓> key, then adjust it with <←> or <→> key.

To set up reference value of vibration, refer to the manual of PC software.

3.8. Measuring

After confirming all the settings, we can measure as follows:

- Attach the cables and mount the sensor and trigger correctly. (Refer to section 2.2)
- Switch the power on. (Refer to section 2.2)
- SENDIG-903 enters into the Measure Menu automatically. After all the parameters are confirmed, you can begin measuring by pressing <Enter> key.

The screen will show:

```

[SENDIG-903]
Name: POINT# ...
Route: 1
Input-Mode: Sens (or Volt.)
AlmWv-Mode: Vel.
Trig-Mode: Free-Shot
Freq-Range: AUTO. (Hz)
Sens-Scale: 5.00
AlarmScale: 3.00
-----
[←][→] To Change
[↑][↓] To Move
  
```

Wait A Moment ...

After a while, such data will be displayed on the screen:

```

NEW data  OLD date
HFA: ***** / ***** m/s2
ACC: ***** / ***** m/s2
VEL: ***** / ***** mm/s
DIS: ***** / ***** μm
  
```

Then, you can see:

Wait A Moment ...

Now, SENDIG-903 is collecting waveform according to the parameters of AlmWv-Mode, which is set up in Measure Menu.

After collecting waveform, the result, which is one of the following five, will be displayed on the screen.

- Battery Voltage Low, Please Recharge it
- No Problem Found
- Not A Stable Signal
- Signal Too Strong, Please Check it
- Signal Too Weak or Sensor Problem

For “Not A Stable Signal”, it indicates that measured signal possibly alters too fast. You need to measure it again and SENDIG-903 will adjust the measuring range automatically for gaining the genuine signal.

For “Signal Too Strong”, it suggests that the input signal is too strong indeed and the unit will alarm. You can save the waveform and analyze it elaborately.

When “Signal Too Weak” is shown, please check the sensor and the cable to make sure the sensor and cable linked well. Measure it again if everything OK.

NOTE: Before the measurement result appears, don't press any key or touch the sensor. Otherwise, the spectrum will distort.

4. USING THE MODE MENU

Press <Mode> key, the following will be shown:

```
Note Book
Speed-Measurement
Format Memory
Save Wave
```

4.1. Note Book

The vibration of machines usually correlates with other parameters. For example, the pressure of lubricating oil and bearing temperature can directly reflect the condition of the sliding bearing and influence the vibration. High temperature of motor coil generally means short circuit or overload and so will influence the vibration. As a result, it is important to consider the effect of relative parameters (such as pressure, temperature, flux, rotate speed, etc.) for the fault diagnosis and comprehensive condition evaluation. The function of Note Book is to save these parameters.

After entering into Mode Menu, select Note Book with <↑> or <↓> key, then press <Enter> key. The screen displays the following:

```
(1) Type: Temperature
(2) Old : xx.xxxx
    New : xx.xxxx
(3) Note: 0=Ok
```

move the cursor to the item that you want to modify with <↑> or <↓> key, then adjust it with <←> or <→> key.

(1) Type:

Select parameter from the followings:

- Temperature
- Pressure
- Load or Current
- Other Parameters

(2) Old, New:

They are seven-digit floating point numbers, which denote old data, new data of the parameter. You can modify them with <←> or <→> key. These parameters and forenamed measured value should be stored together to diagnose the faults of machines. **The process: input these parameters firstly, then measure the vibration.**

(3) Notes:

When the collector stores vibration data, a fuzzy evaluation of the on-site machine can

be stored too, so that we can send it to the database of computer as additional information. SENDIG-903 offers ten fuzzy condition codes to be selected:

- 0, Ok
- 1, Not In Use
- 2, Seal Leaking
- 3, Much Noise
- 4, Oil Level Low
- 5, Very Hot
- 6, Bear. Changed
- 7, Seal Changed
- 8, Pre.Flow Low
- 9, Other States

The method of modification refers to the notes at the bottom of the screen.

4.2. Speed-Measurement

The principle of speed-Measurement: adhibit a reflecting slice at the rotation axis. The photoelectric sensor transforms the light pulse that comes from the reflecting slice into electrical pulse. SENDIG-903 can figure out the speed of the rotation axis based on the electrical pulse.

The proceed is as follows:

(1) Connect photoelectric sensor in the “trigger” socket of SENDIG-903 properly and confirm the radiant end of the red light aiming at the reflector that has been attached to the axis.

(2) Switch the power on and enter “Mode” menu:
Move the cursor to Speed-Measurement with <↑> or <↓> key and press <Enter> key. The screen displays:
If you want to quit from Speed-Measurement, please press <Enter> key down and keep for a moment. The rotate speed and waveform can be saved together to diagnose the faults of machines. **The process is to measure rotate speed firstly, then measure the vibration.**

```
Speed(rpm)      ****
Freq.(Hz)       ****

[ Enter ] = Stop!
```

Note: Don't enter into the state of Speed-Measurement at random because SENDIG-903 can't exit automatically on this state and electricity consumption is great.

4.3. Format Memory

Format Memory is a special function for user who is not equipped with computer.

The process is to enter into the “Mode” menu and then enter into the Format Memory screen:

Wait until the RAM checking process finish, then press <Enter> key to format the memory.

After Memory formatted, SENDIG-903 will return automatically to the main menu with factory set parameters.

```
WARNING !
DATA Will Be Lost !
YES = [-] Key
NO = Function Key

CHECKING RAM: xxxxxx
No ERROR Found
```

Note: When you connect SENDIG-903 with computer; please do “Format Memory” before you setup the parameters by computer.

4.4. Save Wave

If you want to store the waveform, please enter into the “Mode” menu, and then move the cursor to Save Wave and press <Enter> key. The screen displays:

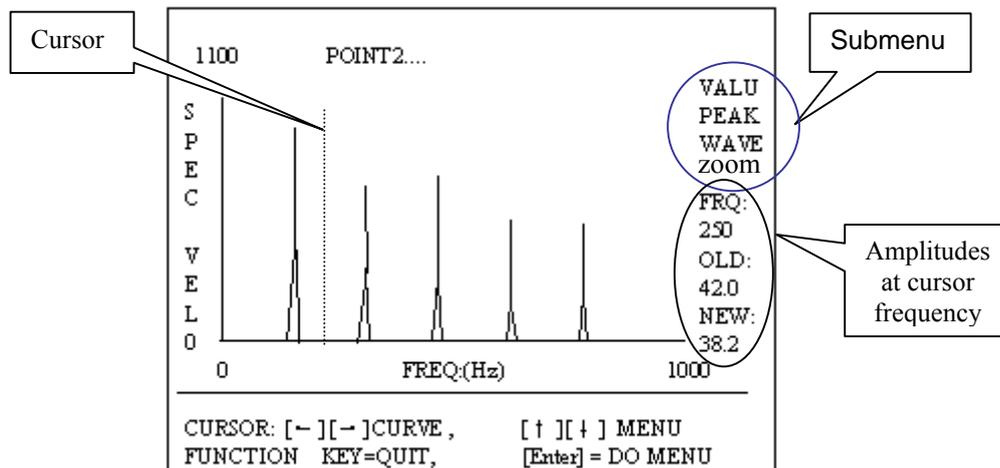
Then, press <Enter> key to store the waveform and the screen will display the serial number of the stored waveform. The stored waveforms can't be erased except format memory. SENDIG-903 can store 62 waveforms and display “Memory Overflow” when the memory is full.

```
VEL. Waveform
Freq:xxxx Hz Trig: N
Press  Enter To Save,
Other Key To Quit.
```

Note: You cannot save the waveform of the former measure point after the measure point's name has been changed.

5. USING THE ANALYSE MENU

SENDIG-903 shows the FFT spectrum with graphics mode. Firstly, set AlmWv-Mode to decide which parameter to be analyzed. Then, measure the vibration. After finishing the measuring, press <analysis> key. The screen displays spectrum graphics:



There are two amplitude spectrums (real line is the amplitude spectrum of the just measured signal, broken line is the amplitude spectrum of the stored signal on the same point) in the middle. At the top right corner of the screen, there are three submenus: VALU, PEAK, and WAVE. At the bottom, there are two notes.

After measurement, you can see two rows of spectrum only when you have not changed the measuring point. Otherwise, when go back to former measuring point; you can only see one row of spectrum. It is the spectrum of the just measured data. If you have not made any measurement at the current point you can only see the reference spectrum come from computer (broken line).

Notes: 1. Submenus:
VALU: characteristic values of vibration

PEAK: peak value of spectrum

WAVE: time-domain waveform

ZOOM: 4 times frequency zoom around the cursor

Select item with <↑> or <↓> key. Press <Enter> key to show.

2. Move the cursor with <←> or <→> key to observe the spectrum value. At the right of screen, there are three data items: FRQ (frequency), OLD (old data, broken line), and NEW (new data, real line). After selected "WAVE", you can observe the 1024-point time-domain waveform with <←> or <→> key.
3. Set-up the "AlmWv-Mode" in the "Measure" menu before measuring.

6. SPECIAL NOTICES

6.1. Sympathetic vibration demodulation analysis

Vibration arising from disfigurement of ball bearing has a feature of low intensity and high frequency (especially at the forepart of fault). When the roller is passing fault position, impact, audio frequency and supersonic vibration will be brought about. Furthermore, the impact makes bearing ring and accessories produce sympathetic vibration. During vibration measurement, it is necessary to separate high frequency signals arising from imbalance, no alignment and so on from low frequency signals.

SENDIG-903 can separate out envelope signal caused by bearing fault through high frequency separation technology and sympathetic vibration demodulation method.

The process is as follows:

- (1) Enter into Measurement menu and move cursor to "AlmWv-Mode" with <↑> or <↓> key.
 - (2) Select parameter "Enve" with <←> or <→> key.
 - (3) Press <Enter> key to measure.
 - (4) Press <analysis> key to observe envelope spectrum and envelope waveform.
- If you want to store the envelope waveform, refer to section 4.4.

6.2. Measure vibration with vortex displacement sensor or inductance velocity transducer

The proceed as follows:

- (1) Check that the plug of sensor is properly connected in the "Volt" socket of SENDIG-903.
 - (2) Enter into Measurement menu and move cursor to Input-Mode with <↑> or <↓> key.
 - (3) Select parameter "Volt" with <←> or <→> key.
 - (4) Press <Enter> key to measure.
 - (5) Press <analysis> key to observe the spectrum and waveform of voltage signal.
- If you want to store waveform, refer to section 4.4.

6.3. Data store

It's automatically to store the characteristic value and spectrum. Each time you change the measurement point name, SENDIG-903 will automatically check if the former measurement point has new data. If it has, the new data will be saved (including

measurement parameter, peak value of ACC or voltage, rms value of VEL, Enve, or voltage, peak-to-peak value of DIS or voltage). The old data will be lost automatically after saving new data because they occupy the same memory space.

If you want to further analyze and diagnose the vibration of measurement point, you can store the waveform of vibration to send it to the computer in future. The operation refers to section 4.4 "Save Wave".

6.4. Communicate with computer

It's easy to connect SENDIG-903 with computer. When the serial communication cable is connected properly and the power is switched on, SENDIG-903 will wait for the computer's command. As soon as SENDIG-903 receives the computer's command, it will communicate with computer at once. Before collecting, you can send the parameters that are set up in the computer beforehand to SENDIG-903 through the serial communication cable. These parameters include Point Name, Input-Mode, Sensor-scale, Alarm-scale, reference spectrum, and reference value of displacement, velocity, acceleration and Envelop). Then you can measure, collect and compare data with the old one with SENDIG-903 on the spot. New data can be sent to the maintenance database or signal analysis software package by serial communication cable.

Note: Before SENDIG-903 receives the computer data; please format memory firstly (refer to 4.3 "Format Memory"). Otherwise, the function of data-store could be affected.

7. USING DYNAMIC BALANCER

7.1. Introduction

The most convenient method to eliminate rotor's imbalance is making dynamic balance on the spot. So, on the base of vibration measurement and signal analysis, SENDIG-903 adds the functions of phase measurement and dynamic balance calculation.

7.2. 1-plane balancing

The flow chart of 1-plane balancing can be found in Figure 3:

7.2.1. What is 1-plane rotor imbalance?

Rigid rotor works under the speed far less than its first-order critical rotate speed and its deformation can be neglected. When the quality of the rigid rotor almost focuses on a disc, namely the ratio of its length and its diameter is less than 0.5, we can do 1-plane dynamic balance on it and gain satisfactory result. But for the flexible rotor, the deformation cannot be neglected. So its method of balance differs from rigid rotor. However, the rotor with single imbalance plane can also be balanced according to the method of 1-plane balance of rigid rotor. For above, whether the rigid or flexible rotor, its quality of imbalance always focuses on one disc, so both of them can be balanced according to the method of 1-plane rotor balance. In the mineral plant and manufactory, such rotating machines are ubiquitous, such as pump, ventilator etc.

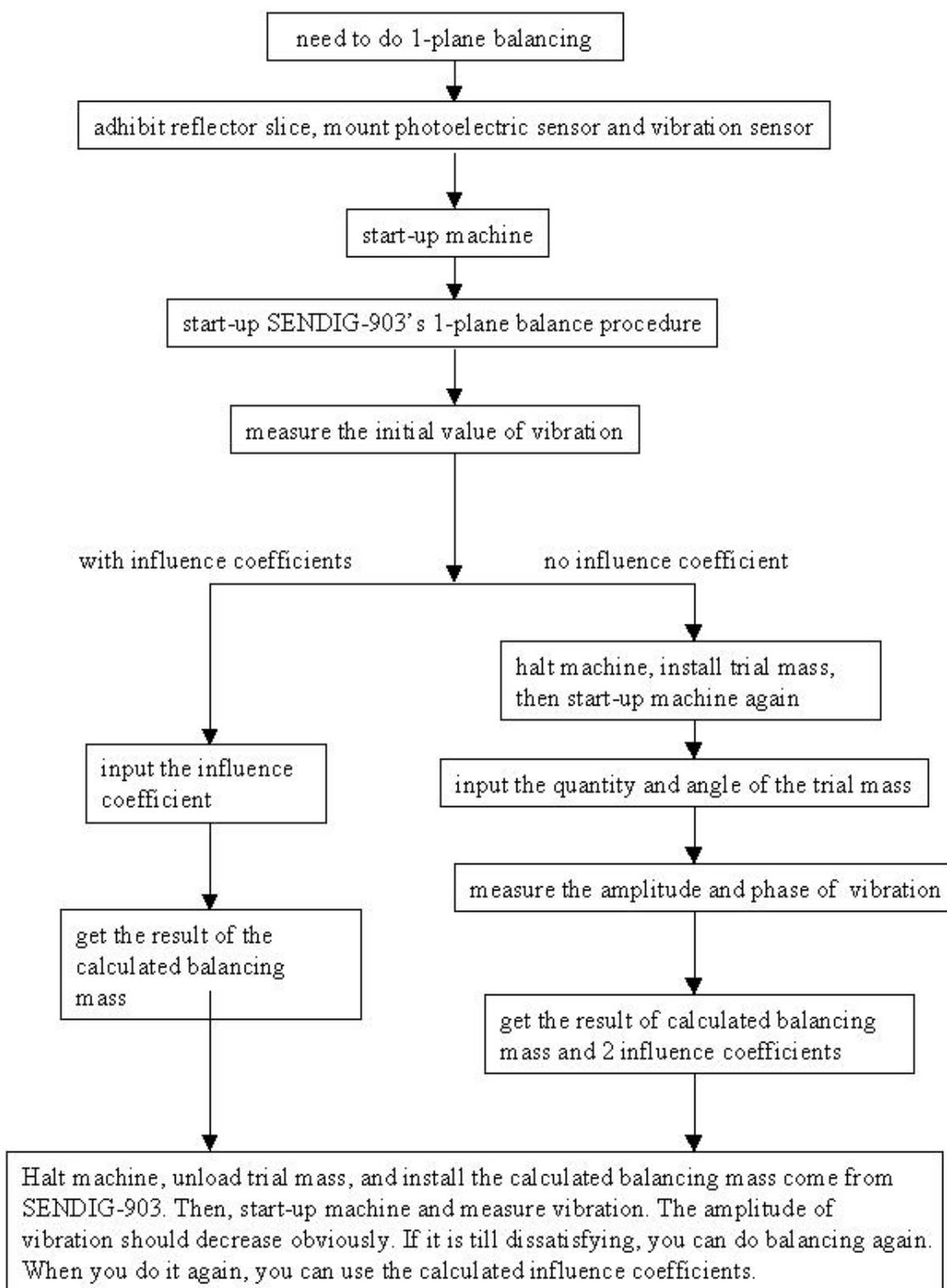


Figure 3. Flow chart of rotor's 1-planes balancing

7.2.2. Principle of 1-plane balancing

SENDIG-903's 1-plane balance adopts the method of influence coefficient, which is also called balance method of 1-plane measure phase. Just as its name implies, it's desirable to do the measurement with the phase of base-frequency vibration when measuring the vibration amplitude of rotor. The base-frequency vibration can be indicated as vector. The process of 1-plane balance is as follows:

- (1) Measure and gain the initial base-frequency vibration vector (A0) under the scheduled rotate speed.
- (2) Load the proper trial mass (M) on the rotor and then measure vibration vector (A01) under the condition of the same rotate speed.
- (3) Calculate the balance mass (Q) which should be load on the rotor according to the following formula:

$$Q = - M \times A0 / (A01 - A0)$$

During the balancing, all the vibration should be measured under the same rotate speed because of the imbalance force of rotor relates with the rotate speed.

7.2.3. Process of 1-plane dynamic balancing

7.2.3.1. Preparation

- (1) Affirm that machine has fault of imbalance and that it can be eliminated by the method of 1-plane balance. Once the machine has heavy vibration, we should do frequency analysis with the vibration signals firstly. Generally, the probability of imbalance is higher. So, when the vibration signals include high rotation-frequency vibration and less harmonic frequency wave, meantime without evidence of other faults, very possible it is the fault of imbalance.

- (2) Mount sensor

Vibration sensor: it should be disposed in the horizontal direction (or vertical direction) of the rotor bearing, or on the base frame. Because dynamic balance is vector calculus, the position and direction of the vibration sensor should keep unchanged in the course of the balancing.

Photoelectric sensor: adhibit a reflecting or unreflecting adhesive paper (according to the condition of the rotor's surface) to a visible place of the rotor or its axis. Photoelectric sensor can give SENDIG-903 1 electric pulse per turn of the running rotor. Not only the rotate speed can be measured but also the vibration signals can be compared with pulse signals. So the phase of the rotation-frequency vibration signals can be gained. During the balancing process, the position of the reflecting adhesive paper, the position and direction of the photoelectric sensor should keep unchanged.

- (3) Link cables

Connect vibration sensor and photoelectric sensor with SENDIG-903 properly.

- (4) Start-up the machine and make it run at the due rotate speed of balance.

7.2.3.2. Operation

- (1) Switch off SENDIG-903's power, press down the red button (at the right-hand side of the panel).
- (2) Switch on SENDIG-903's power, the screen displays the balancing menu:

```
[BALANCE-903D]
1-Plane Balancing
2-Planes Balancing
Setting
```

Move cursor to "Setting" with <↑> or <↓> key. Press <Enter> key to enter the parameter setting sub-menu of dynamic balancing:

```
Meas-Mode:  Dis.
InputMode:  Sen.
Sen-Scale:  *.**
```

Move cursor with <↑> or <↓> key to a parameter and adjust it with <←> or <→> key. Press any key else to come back to the main

menu.

Move cursor to “Meas-Mode” and select the measure mode. The options include ACC, Vel, and Disp. To select a suitable one, refer to the figure 2.

Move cursor to “InputMode” and select the input mode. The input modes have Sens and Volt.

Adjust the sensor scale “Sen-Scale” (unit: $m \cdot s^{-2}/pC$) according to the accelerometer's certificate.

(3) In the main balancing menu, move to 1-Plane Balancing with $\langle \uparrow \rangle$ or $\langle \downarrow \rangle$ key and press $\langle \text{Enter} \rangle$ to enter into 1-plane balancing menu. The screen displays:

```
Is Machine Rotating?
RUN!           Result
Step2         Step3
Run0; Plane1; Point1
```

Move cursor to RUN! Press $\langle \text{Enter} \rangle$ key to execute.. Affirm the rotate speed had achieved the speed at which you want to do balancing. Then, press $\langle \text{Enter} \rangle$ key to measure initial vibration. Soon, The screen displays:

```
Speed: **** (rpm)
Phase: **** °
Amplitude: **** μM
← = Key To Next Step
```

When rotating speed, phase and amplitude of vibration are steady, press $\langle \text{Enter} \rangle$ key for a moment and then the initial value should be displayed:

```
Have Influence Coef.?
Yes&Input  Measure
```

1) If influence coefficient is known, select Yes&Input. The screen displays:

```
Influence Coef. Is
                μM /g °
↑↓ = FAST ← → =SLOW
← = NEXT STEP!
```

Adjust the influence coefficient with $\langle \uparrow \rangle$, $\langle \downarrow \rangle$ or $\langle \leftarrow \rangle$, $\langle \rightarrow \rangle$ key. Then press $\langle \text{Enter} \rangle$ key and the correction weight and angle will be displayed:

```
Correction Should Be
    ×× g    ×× °
Influence Coef. Is
    μM /g
```

2) If influence coefficient is unknown, go to “Measure” with $\langle \uparrow \rangle$, $\langle \downarrow \rangle$ or $\langle \leftarrow \rangle$, $\langle \rightarrow \rangle$ key. Then press $\langle \text{Enter} \rangle$ key to measure. The screen displays:

```
Set Trial Mass ->PL1
And Then Input Its
Weight (g)=*.***(g)
And Degree=?
```

You can input the weight and degree of the trial mass with $\langle \uparrow \rangle$, $\langle \downarrow \rangle$ or $\langle \leftarrow \rangle$, $\langle \rightarrow \rangle$ key. Press $\langle \text{Enter} \rangle$ key to affirm. Then the screen displays:

```
Speed: **** (rpm)
Phase: **** °
Amplitude: **** μM
← To Next Step
```

When rotate speed, phase and amplitude of vibration are steady, press $\langle \text{Enter} \rangle$ key. Now, the measurement of phase and amplitude of vibration is finished. The screen

displays the correction weight and degree and the influence coefficient.

Halt machine and unload the trial mass. Install the mass according to the result that comes from SENDIG-903. Then, start machine again and measure vibration. The amplitude of vibration should decrease obviously. If the result is dissatisfactory, you should do balancing again until gain satisfactory outcome. When you do it again, you can use the prior obtained influence coefficient.

NOTE:

- If select “Result” or “Step3” and press <Enter> key, you can observe the conclusion of the prior balancing.
- If select “Step2” and press <Enter> key. It indicates the measurement of initial value is finished (the collector store the result automatically). If the influence coefficient is known, input it. Otherwise affirm the trial mass and input it. If the collector is switched off or the influence coefficient and trial mass are wrong, return to the selecting menu and select “Step2” again.

7.3. 2-planes balancing

The process of rotor's 2-plane field balancing is in figure 4 in the next page.

7.3.1. Principle of 2-planes dynamic balance of rotor

Almost all the balance of single span rotor can be achieved through the method of 2-planes dynamic balance. As a matter of fact, 1-plane dynamic balance is only one special example of 2-planes dynamic balance.

When doing 2-planes dynamic balance, two planes of adding mass and two points of vibration measure are needed. SENDIG-903's 2-planes dynamic balance also adopts the method of influence coefficient. But the difference from 1-plane dynamic balance is that the vibration of two measurement points should be measured when adding trial mass to one of the planes. That's so-called interact effect. 2-planes dynamic balance has four influence coefficients.

The steps to do 2-planes dynamic balance is as followings:

(1) Measure initial value of two measurement points.

Load trial mass to first plane, then measure the vibration of two measurement points respectively.

(2) Load trial mass to second plane, and then measure the vibration of two measurement points respectively.

(3) Gain conclusion of the correction mass.

Of course, if the influence coefficient is known, it can be input directly and the above step (2) can be omitted.

7.3.2. Process of 2-planes dynamic balance with SENDIG-903

The preparation for 2-planes dynamic balance is just as for 1-plane dynamic balance. About the details please refer to section 7.3.3.1. It is necessary, because of the

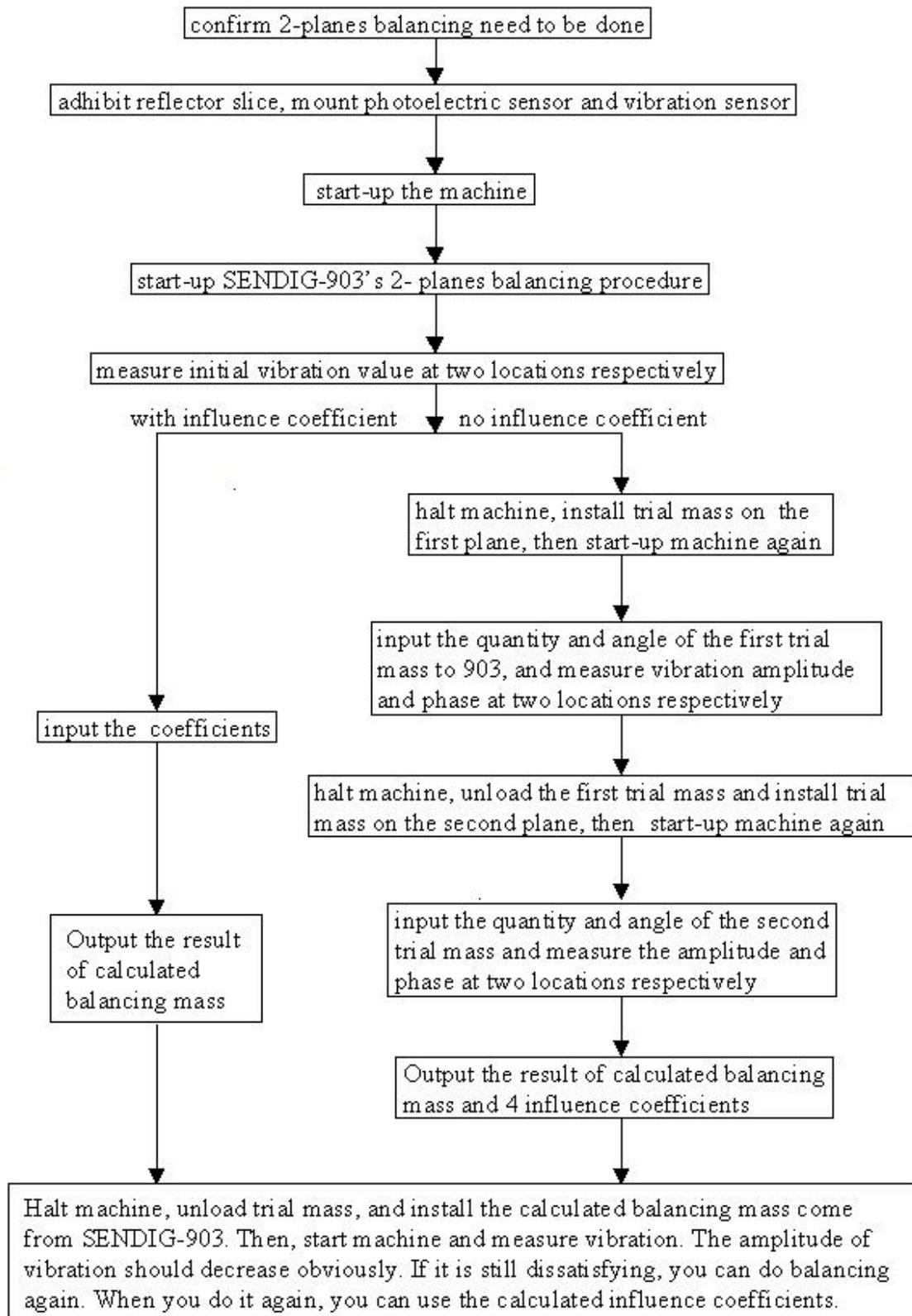
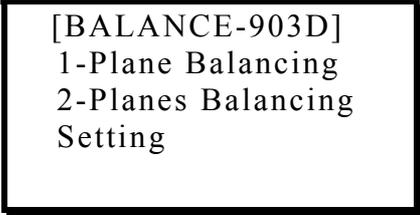


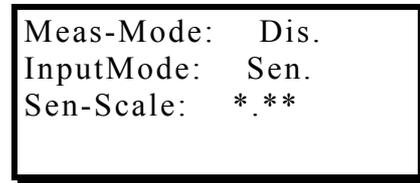
Figure 4. Flow chart of rotor's 2-planes balancing

repetitive vibration measurement of two positions, to make a mark on each measurement point to ensure that each measurement is made in the same place. The process is as followings:

(1) Switch off power, press down the red button (at the right-hand side of the panel). Then switch on power and the screen will display the main menu as followings:



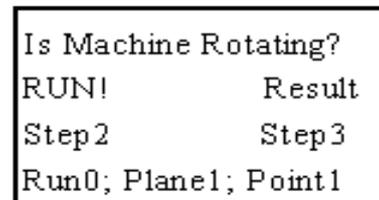
(2) Move cursor to Setting item with <↑> or <↓> key. Press <Enter> key to confirm. At once, the screen displays the parameter setting menu of dynamic balance vibration measurement:



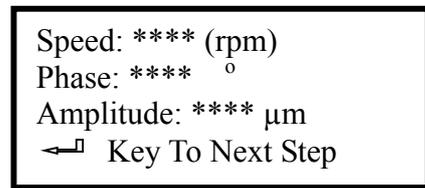
Move cursor with <↑> or <↓> key and adjust the parameter with <←> or <→> key. Press other key to come back the main balance menu.

Move cursor to Meas-Mode. The measure mode involves ACC, Vel, and Disp. The detailed parameter selecting refers to the figure 2. Move cursor to InputMode. The input mode involves Sens and Volt. Sens mode is selected generally when adopt accelerometer. Adjust the sensor scale “Sen-Scale” (unit: m/s²/pc) according to the accelerometer’s certificate.

(3) Under the main balance menu, move cursor to 2-Planes Balancing with <↑> or <↓> key and press <Enter> key enter into 2-planes balancing submenu. Screen displays:



Move cursor to RUN! . When the rotating speed had achieved the speed at which you want to do balance, press <Enter> key to measure initial value of vibration. Soon the screen displays:



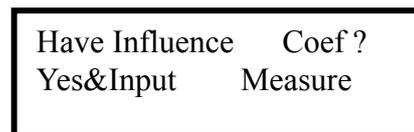
When rotate speed, phase and amplitude of vibration are steady, press down <Enter> key for a moment, and then remove the hand. Now the measurement of the first measurement point’s initial value is finished. Then the screen displays:



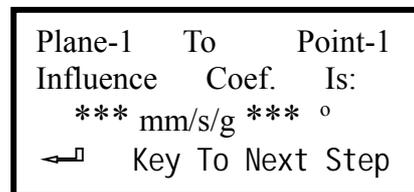
Move cursor to RUN! and press <Enter> key to measure the initial vibration value of the second measurement point.

When rotate speed, phase and amplitude of vibration are steady, press down <Enter> key and remove the hand after a moment. Now, the measurement of the second measurement point’s initial value is finished.

(4) After finish the measurement of initial value, the screen displays:



If influence coefficient is known, select Yes&Input and press <enter> key. Then the screen displays:



Now input influence coefficient of plane-1 to point-1 with <↑> or <↓> or <←> or <→> key. Then press <Enter> key to confirm and screen displays:

```
Plane-1 To Point-2
Influence Coef. Is:
*** mm/s/g *** °.
←□ Key To Next Step
```

Now input influence coefficient of plane-1 to point-2 with <↑> or <↓> or <←> or <→> key. Then press <Enter> key and the screen displays:

```
Plane-2 To Point-1
Influence Coef. Is:
*** mm/s/g *** °.
←□ Key To next Step
```

Now input influence coefficient of plane-2 to point-1 with <↑> or <↓> or <←> or <→> key. Then press <Enter> key and the screen displays:

```
Plane-2 To Point-2
Influence Coef. Is:
*** mm/s/g *** °.
←□ Key To Next Step
```

Input influence coefficient of plane-2 to point-2 with <↑> or <↓> or <←> or <→> key.

When all were input correctly, press <enter>key to gain the calculated quality and angle of the balancing mass.

```
Correction Should Be
PL1: ***g *** °.
PL2: ***g *** °.
←□ Key To Next Step
```

Halt the machine and install the balancing mass according to the given values. If the power is switched off by accident, you can switch on again and select Result item to regain the calculation result of balance.

(5) If the influence coefficient is unknown, you must select Measure item and the screen will display:

```
Set Trial Mass->PL1
And Then Input Its:
Weight=***(g)
Angle=*** °
```

Halt machine, load the selected trial mass on the plane-1, move the cursor with the <↑> or <↓> or <←> or <→> key and input the actual weight and angle of the trial mass. When finished, press the <Enter> key. Then the screen displays:

```
Is Machine Rotating?
RUN!
RUN1; Plane1; Point1
```

When the rotate speed is steady, press <Enter> key to measure the vibration of the first measurement point with the plane-1's trial mass. When phase and amplitude of vibration are steady, then press <Enter> key again to store the measurement result. Then screen displays:

```
Is Machine Rotating?
RUN!
RUN1; Plane1; Point2
```

After the sensor of the second measurement point is connected properly, press <Enter> key to measure the vibration of the second measurement point with the plane-1's trial mass. When rotate speed, phase and amplitude of vibration are steady, press <Enter> key again to store the measurement result.

Now, the measurement of each measurement point with the plane-1's trial mass is finished. At the same time, the screen displays:

```
Set Trial Mass->PL2:
And Then Input Its:
Weight=***(g)
Angle=***°
```

Halt machine and unload the first trial mass. Then load the selected trial mass on the plane-2, and input the actual weight and angle of the trial mass. Then press <Enter> key. The screen displays:

```
Is Machine Rotating?
RUN!
RUN2; Plane2; Point1
```

When the rotate speed is steady and the sensor of the first measurement point is connected properly, press <Enter> key to measure the vibration of the first measurement point with the plane-2's trial mass. Then the screen displays:

```
Speed: **** (rpm)
Phase: **** (°)
Amplitude: **** mm/s
← Key To Next Step
```

When rotate speed, phase and amplitude of vibration are steady, press <Enter> key for a moment to store the measurement result. Then the screen displays:

```
Is Machine Rotating?
RUN!
Run2; Plane2; Point2
```

After the sensor of the second measurement point is connected properly, press <Enter> key to measure the vibration of the second measurement point with the plane-2's trial mass. When rotate speed, phase and amplitude of vibration are steady, press down <Enter> key for a moment to store the measurement result.

Now, the measurement to every measurement point with the plane-2's trial mass is finished. The screen shows the result:

```
Correction should be
PL1: *** g *** .°
PL2: *** g *** .°
← Key To Next Step
```

Now, press <Enter> key, four influence coefficients will be shown in turn.

They are respectively the influence coefficient of plane-1 to point-1, plane-1 to point-2, plane-2 to point-1, and plane-2 to point-2.

```
*** mm/s/g *** .°
*** mm/s/g *** .°
*** mm/s/g *** .°
*** mm/s/g *** .°
```

Halt machine, unload trial mass, and install balance mass at the same radius and angle according to the result given by SENDIG-903. Then start-up machine again and measure vibration. The amplitude of vibration should decrease evidently. If the result is dissatisfactory, you can do dynamic balance again until gain satisfactory outcome. If you do it again, you can use the prior influence coefficient.

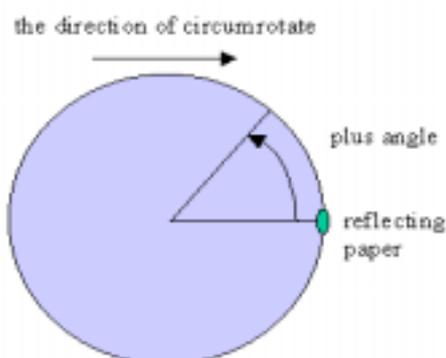
NOTE:

- Select Result and press <Enter> key, you can observe the conclusion of the prior balancing.
- Select Step2 and press <Enter> key. It indicates the measurement results of the initial vibration (the collector store the result automatically). If the influence coefficient is known, input it. Otherwise affirm the trial mass and load the first trial mass. If the collector is switched off or the influence coefficient and trial mass are wrong, return to the main menu and select Step2 again.
- Step3 means that the measurement of the first trial mass has been finished and the first trial mass was unloaded. You may load the second trial mass on plane-2 and then continue. If the power is switch off or the second trial mass is wrong, return to the main menu and select Step3 again. If the influence coefficient is known, it can be input directly and the step2 and step3 can be omitted.

7.4. Notices during the operation

7.4.1. Direction of phase

The definition of phase usually takes the reflecting slice as zero phases. According to custom and international tradition, SENDIG-903 takes the direction which is contrary to the direction of circumrotate as the plus direction. As following:



7.4.2. Select parameter and parameter's dimension

The parameter of vibration can selected from Dis, Vel, Acc, and Vol . In turn, the dimension of the influence coefficient is:

$$\mu\text{m/g}^{\circ}; \text{mms}^{-1}/\text{g}^{\circ}; \text{ms}^{-2}/\text{g}^{\circ}; \text{V/g}^{\circ}$$

Because different parameter will influence the precision of measure, you must select the measurement parameter according to the range of rotate speed:

Rotation speed (rpm)	0 ~ 10000	>10000
Balancing parameter	Dis or Vel	Vel or Acc

7.4.3. Confirm the weight of the trial mass

If trial masses are too light, the vibration will hardly change so no accurate correction mass can be calculated. If trial masses too heavy, the vibration will be exacerbate, even damage the machine. There are two methods to select the trial mass.

- (1) According experience and the condition of same style machine to select trial mass.
- (2) Calculate depending on formula. Firstly, gain the approximate grade of balance precision according to ISO1940. Then the trial mass (m) can be estimated by:

$$m = \frac{30000 \times M \times G}{\pi \times n \times r} \times (5 \sim 10) \text{ (g)}$$

where: M(kg): the weight of rotor
 G(mm/s): the grade of balance precision
 n(rpm): maximal rotate speed of the balanced machine
 r(mm): the locating radius of trial mass
 m(g): the weight of trial mass

7.4.4. Confirm the angle

According to the vector graph analysis, when the phase difference between the measured vibration with trial mass and without trial mass is too small, the calculation error of influence coefficient and correction mass will become large. So, if you find the phase difference less than 25° , you need to increase the weight of the trial mass or change its angle and to measure again.

To decide whether the measure result is useful, you can refer to the table as below:

	$\Delta V < 25\%$	$\Delta V > 25\%$
$\Delta\Delta\Phi < 25^\circ$	Increase trial mass weight	Change trial mass angle
$\Delta\Phi > 25^\circ$	Results is useful	Results is useful

Where $\Delta\Phi$ is the phase difference between vibration vector with trial mass and without trial mass. ΔV is the difference between amplitudes with trial mass and without trial mass, all referred to the base-frequency vibration.

7.4.5. Radius

Each time's trial mass and the correct mass must have the same radius. Otherwise, you have to adjust the weight of mass according to inverse ratio.

8.MAINTENANCE

8.1. PHILOSOPHY

The SENDIG-903 has no user-serviceable components. If the operation of the unit is suspect, consult your dealer for advice. This section will cover those regular maintenance items that are the responsibility of the user.

8.2. VERIFYING

The transducer and trigger need be checked to ensure validity. These items are calibrated at the factory and need not require adjustment. However, if the unit's calibration is suspect, your agent can assist in verifying its proper operation. It is recommended that the unit be checked once yearly by qualified personnel.

8.3. BATTERY

The power of SENDIG-903 is a Ni-MH rechargeable battery. If the unit is unused long-term, you need to charge it before use. Full charge needs five hours at least. The unit can be used for 8 hours of continuous operation with full charged battery.

The AC adapter provided is for battery charge. To do this, the adapter should be plugged into the “serial•charge” socket, which is at the right side of the instrument.

The battery requires no maintenance but charging and it is not considered a user-serviceable component of the unit. Any attempt to open the unit is strongly discouraged and may invalidate the warranty.

The internal battery has a very large short circuit current capacity. Extreme caution should be exercised when working in its proximity. Disconnect the battery before servicing the unit. When replacing the battery, it is recommended that it be purchased from SENDIG, to ensure original equipment quality.

If any problem with the battery appears to exist, contact SENDIG for advice immediately.

8.4. CLEANLINESS

The SENDIG-903 is a delicate, scientific instrument, even though it is a portable field unit. Reasonable care should be taken to avoid the ingestion of dust, moisture, etc., into the unit. The same care should be taken for the transducers.

In addition, when you are finished with the measurement, disconnected the transducer and trigger and stow them back in their storage compartments. It is a good idea to wipe the cables down with a cloth to remove excess water, as this can cause corrosion and mildew if trapped in the case.

Care should be taken not to spill any liquids inside the unit.

9. SPECIFICATIONS

- Input signal: Accelerometer, and voltage
- Amplitude ranges & Frequency Response

	Amplitude ranges	Frequency Response
Displacement	3 – 5000 μm peak-peak	10 - 500 Hz
Velocity	0.2 - 200mm/s true RMS	10 - 1000 Hz
Acceleration	0.5 - 250m/s ² peak	20 - 5000 Hz
Envelope	0.1 – 20unit true RMS	5-1000Hz from 15-40 kHz
Voltage	0.1 - 10V peak-peak	10 - 2000 Hz

- Amplitude spectrum analysis: 100 lines to 400 lines (zoom), Hanning windowed
- Frequency range of spectrum analysis: 100, 200, 500, 1k, 2k, 5k, 10kHz
- Data storage: 62 waveforms of 1024-points and 270 data sets
- Notepad: 10 condition codes for visual inspection
- Output: RS232C for communication with PC
- Power: Ni-MH rechargeable battery for 8 hours continuous operation, low battery warning
- Operating Environment: 0~55 °C, 90% humidity non-condensing
- Rotating speed measurement with photocell sensor
- Dynamic Range: 60dB with 48dB adjustable gain range
- Anti-aliasing filter: 8th order elliptic low-pass
- Dimensions: 21×13×4 cm; Weight: 1.2 kg (Include batteries)

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