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INSTRUMENTATION

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Vibrating Wire Monitor

User's Manual

Rev. 1.0

Record of updates

Version	Date	Updates performed
1.0	01/2020	First release

DISTRIBUTORS

U.S.A.

GMW Associates
www.gmw.com
sales@gmw.com

Japan

Hayashi-Repic Co., Ltd.
www.h-repic.co.jp
sales@h-repic.co.jp

India

GEEBEE International
www.geebeeinternational.com
info@geebeeinternational.com

China

Beijing Conveyi Limited
www.conveyi.com
sales@conveyi.com

REPRESENTATIVE AGENT

South Korea

Seyoung Co., Ltd
www.seyoungsys.com
apark@seyoungsys.com

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INITIAL INSPECTION

It is recommended that the shipment be inspected immediately upon delivery. If it is damaged in any way, contact Bergoz Instrumentation or your local distributor. The content of the shipment should be compared to the items listed on the invoice. Any discrepancy should be notified to Bergoz Instrumentation or its local distributor immediately. Unless promptly notified, Bergoz Instrumentation will not be responsible for such discrepancies.

WARRANTY

Bergoz Instrumentation warrants its beam current monitors to operate within specifications under normal use for a period of 12 months from the date of shipment. Spares, repairs and replacement parts are warranted for 90 days. Products not manufactured by Bergoz Instrumentation are covered solely by the warranty of the original manufacturer. In exercising this warranty, Bergoz Instrumentation will repair, or at its option, replace any product returned to Bergoz Instrumentation or its local distributor within the warranty period, provided that the warrantor's examination discloses that the product is defective due to workmanship or materials and that the defect has not been caused by misuse, neglect, accident or abnormal conditions or operations. Damages caused by ionizing radiations are specifically excluded from the warranty. Bergoz Instrumentation and its local distributors shall not be responsible for any consequential, incidental or special damages.

ASSISTANCE

Assistance in installation, use or calibration of Bergoz Instrumentation beam current monitors is available from Bergoz Instrumentation, 01630 Saint Genis Pouilly, France. It is recommended to send a detailed description of the problem by email to info@bergoz.com.

SERVICE PROCEDURE

Products requiring maintenance should be returned to Bergoz Instrumentation or its local distributor. Bergoz Instrumentation will repair or replace any product under warranty at no charge. The purchaser is only responsible for transportation charges.

For products in need of repair after the warranty period, the customer must provide a purchase order before repairs can be initiated. Bergoz Instrumentation can issue fixed price quotations for most repairs. However, depending on the damage, it may be necessary to return the equipment to Bergoz Instrumentation to assess the cost of repair.

RETURN PROCEDURE

All products returned for repair should include a detailed description of the defect or failure, name and fax number of the user. Contact Bergoz Instrumentation or your local distributor to determine where to return the product. Returns must be notified by fax prior to shipment.

Return should be made prepaid. Bergoz Instrumentation will not accept freight-collect shipment. Shipment should be made via UPS, FedEx or DHL. Within Europe, the transportation service offered by the Post Offices "EMS" (Chronopost, Datapost, etc.) can be used. The delivery charges or customs clearance charges arising from the use of other carriers will be charged to the customer.

VWM SET

You just received your VWM, verify that the material corresponds to what was ordered:

Order codes	*Comments*
VWM-S-1W-A5	1-wire 5-mm aperture
VWM-S-1W-A20	1-wire 20-mm aperture
VWM-S-1W-A40	1-wire 40-mm aperture
VWM-S-1W-A60	1-wire 60-mm aperture
VWM-FEE	Front-End-Electronic (supports two wires)
VWM-2WB	Board supporting 2 wires, located inside the chassis. Its USB port is visible on the chassis front panel.
VWM-RFC	RF-shielded chassis with table-top power supply unit; accommodates up to 6 VWM-2WB boards; supports up to 12 wires.

In addition to the above equipment, two more items are required which are not delivered:
RJ45 cable, Ethernet type, cat. ≥5, max. 50 meters
USB cable ≥1.0

VWM ASSEMBLY

Requirement and tools

1) All new sensors are delivered with a wire pre-installed. Its tension is arbitrary. Its purpose is to allow immediate functional check of the sensor.

2) To install new wire, its length should be approximately 60mm longer than the sensor.

3) Wire must be clean without visible damage or bending.

4) Necessary tools:
   - Screwdrivers with hexagonal ball heads 1.5mm, 2mm and 2.5mm
   - Tweezers
   - 2-3 surgical-style clamps
   - Scales with range ≥0.5kg
   - Set of weights to hook to surgical clamp
   - Magnifying glass
   - DVM

5) All sensors are thoroughly cleaned for UHV before shipment. A Residual Gas Analysis is attached. If sensors are to be used in UHV, it may be necessary to clean them again after manipulation. Laboratory-standard UHV cleaning techniques can be applied.

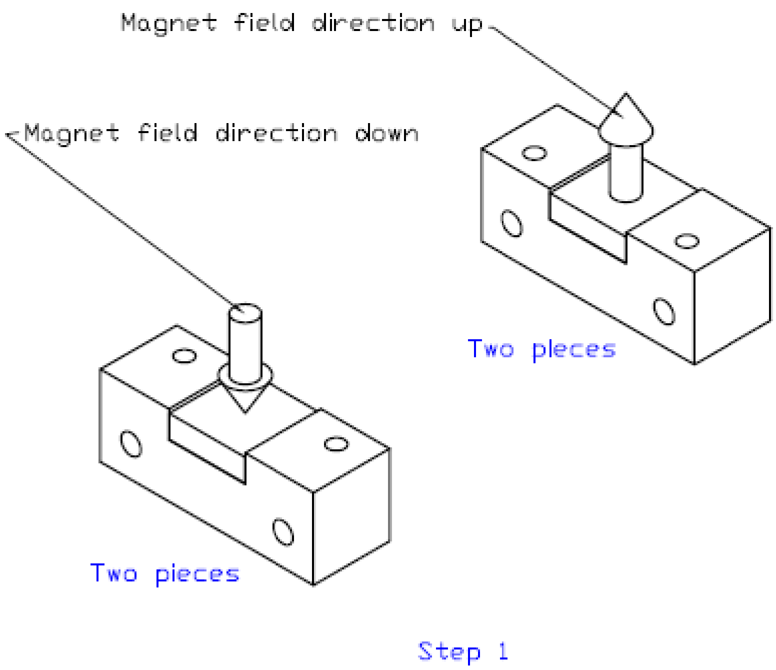
Step 1

Prepare a clean table without any magnetic object.

Carefully install Samarium-Cobalt magnets into magnet pole slots, field orientation as shown below.

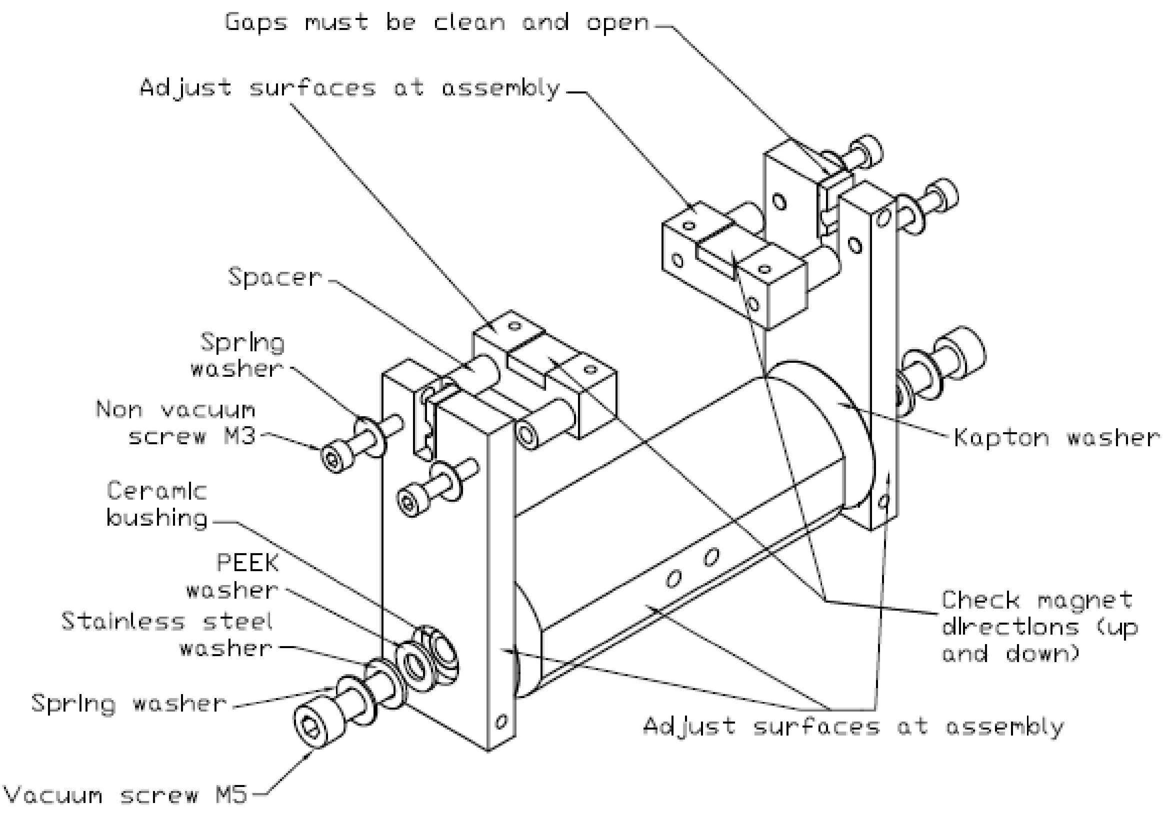
Note:

- Magnets are fragile: Don't let them fall!
- Magnets are very strong: Keep them away >15 cm from each other and other magnetic object!



Step 2

VWM assembly



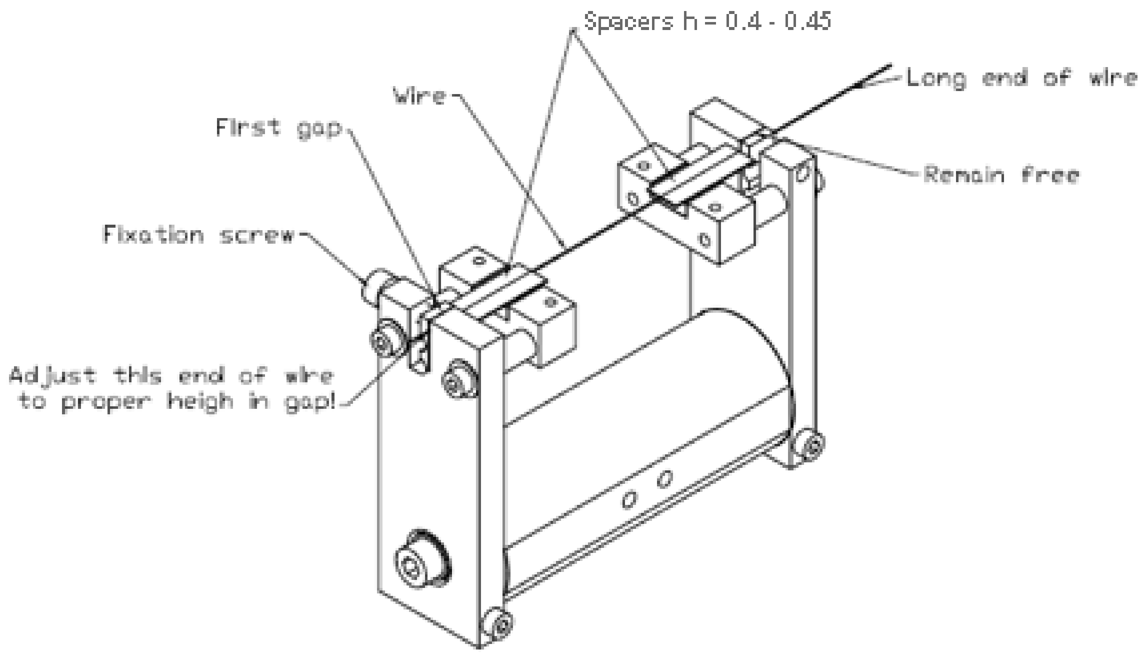
Step 2

- All parts must be clean.
- Gaps on the clips must be opened.
- Test that clips are electrically isolated.

Step 3

To install wire, use spacers of thickness 0.4-0.45mm to place the vibrating wire at the center of the magnetic gap.

It would be better to have these spacers made of a magnetic material, to maintain them more easily when the VWM is in a vertical position (see next step).



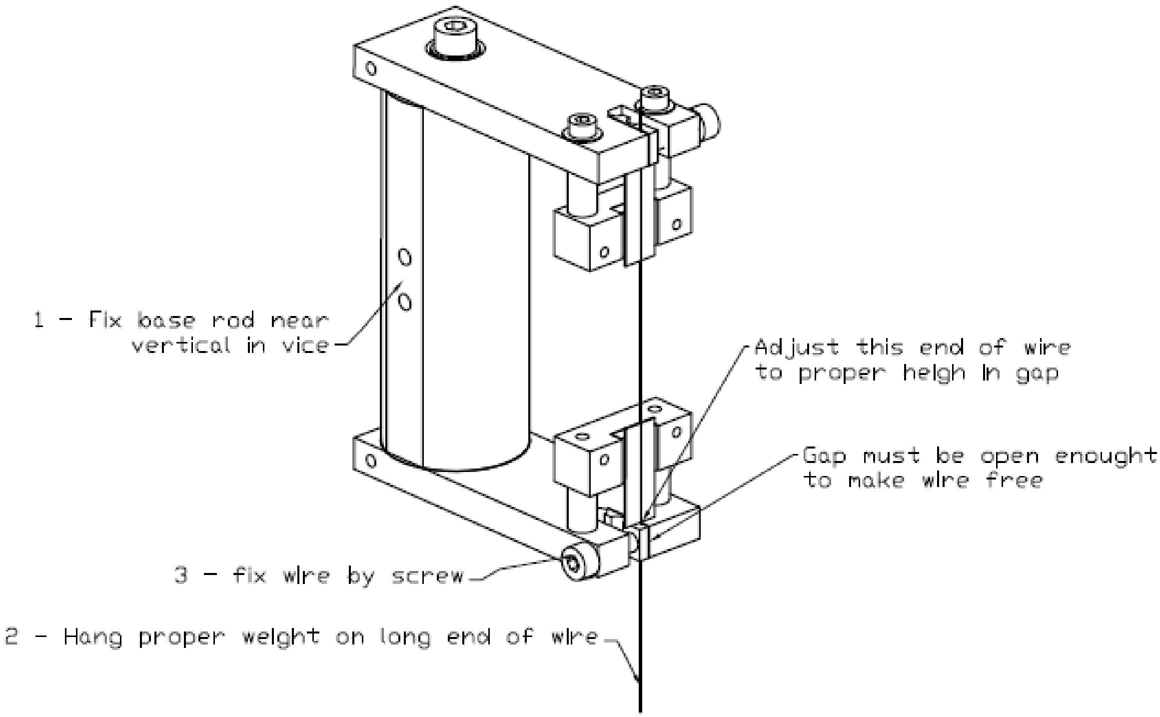
Step 3

Note: Screws must be tightened firmly, with care.

Step 4

Hold the VWM as shown below.

Check that the down clip gap is open enough to keep the wire free. Hang the appropriate weight at the end of the wire using a surgical-style clamp. The value of the proper weight can be found by running the VWM_Choice_Rev2.0 program.



Step 4

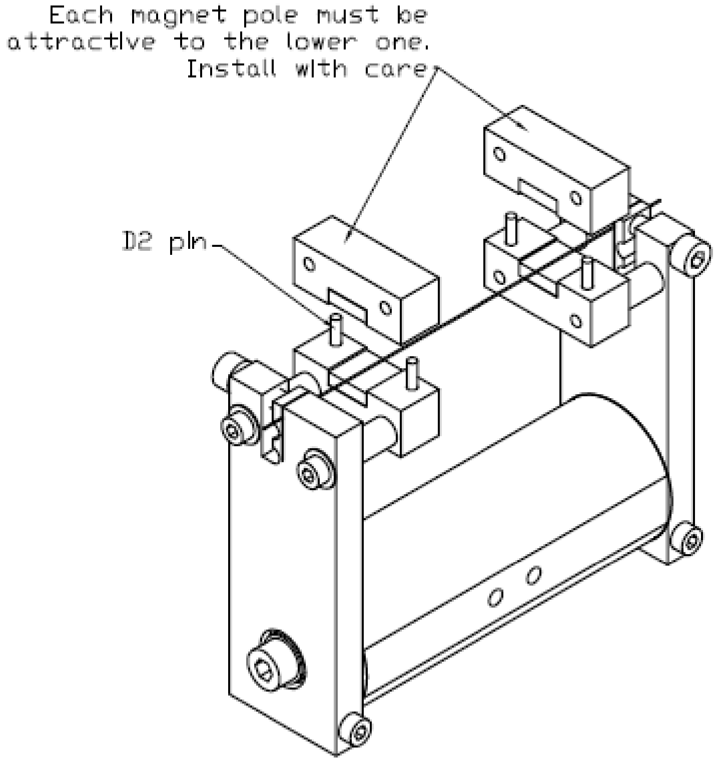
Note:

- Screws must be tightened firmly, with care.
- Carefully remove the spacers by shifting them along the wire.

Once the wire assembly is completed, cut the extraneous wire length.

Step 5

Cover each magnet pole with its corresponding part, it must be attracted to the lower one.

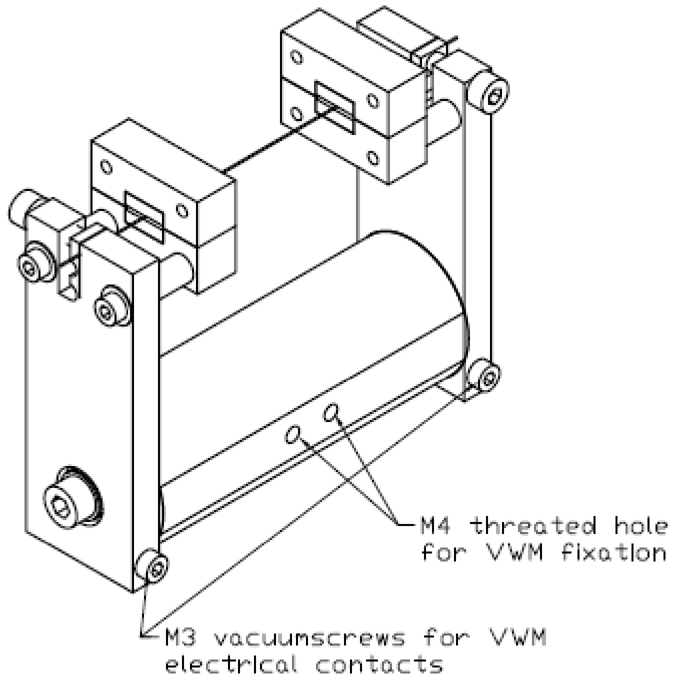


Step 5

Check with magnifying glass that the wire passes through the center of the magnetic gaps.

Step 6

VWM-S-1W assembly is now complete.



Step 6

Measure the wire resistance between the clips using the DVM. Its value must be in range with the wire resistance calculated by the VWM_Choice_Rev2_0 program.

Connect sensor wires to VWM by two M3 vacuum screws on the clips sides.

Four M4x6mm threaded holes are provided for VWM fixation. Distance between holes is 10 mm.

GRAPHICAL USER INTERFACE

Prerequisites

This chapter describes how to use the Demo readout program to measure the VWM frequency. It uses the program named "StringGenerator 1.0" (String Generator version 1) delivered on USB The application is written in Visual Basic version 6.0.

Prerequisites to use "StringGenerator 1.0":

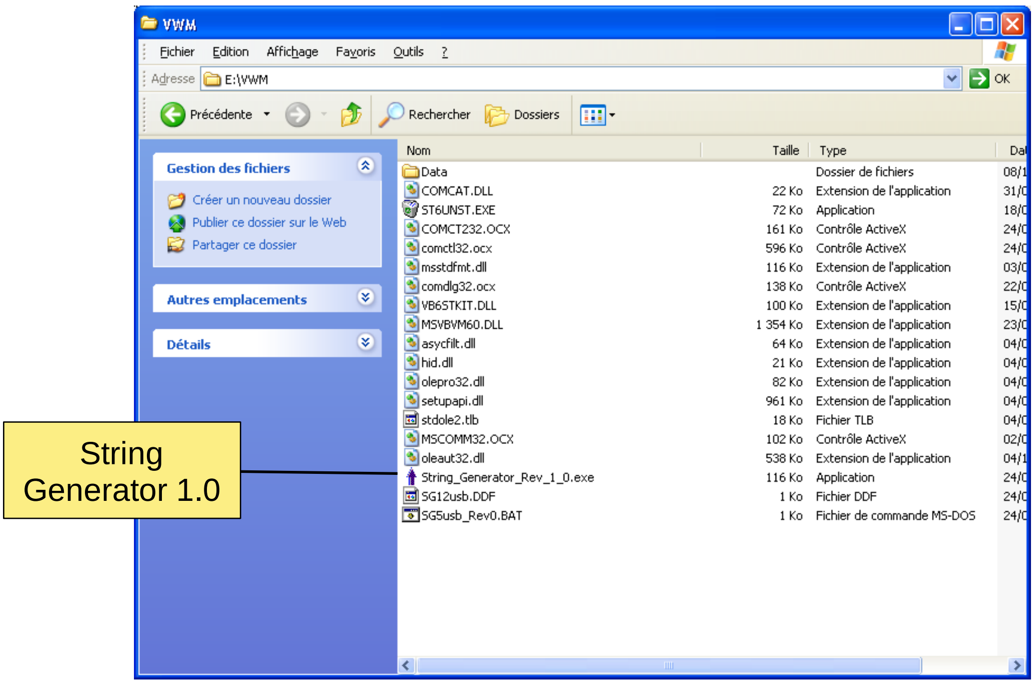
128Mo RAM, 8" screen size, USB 1.0 or higher.
Windows XP SP2 or later.

Test Setup

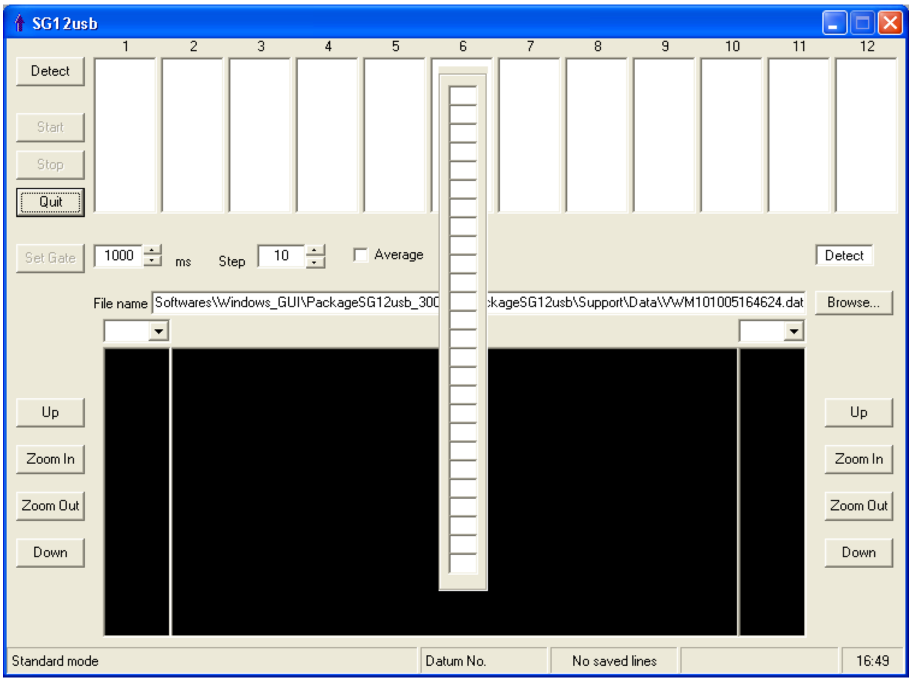
Connect items together as shown, connect +48Vdc table-top power supply to VWM-RFC and plug power supply cable in mains AC voltage 100-240Vac socket. All units are hot-swap and can be connected / disconnected in any sequence.

Once VWM-RFC is powered and all VWM components are connected together, connect the PC to VWM-RFC front panel USB port. It may take one minute for Windows to recognize the new USB device.

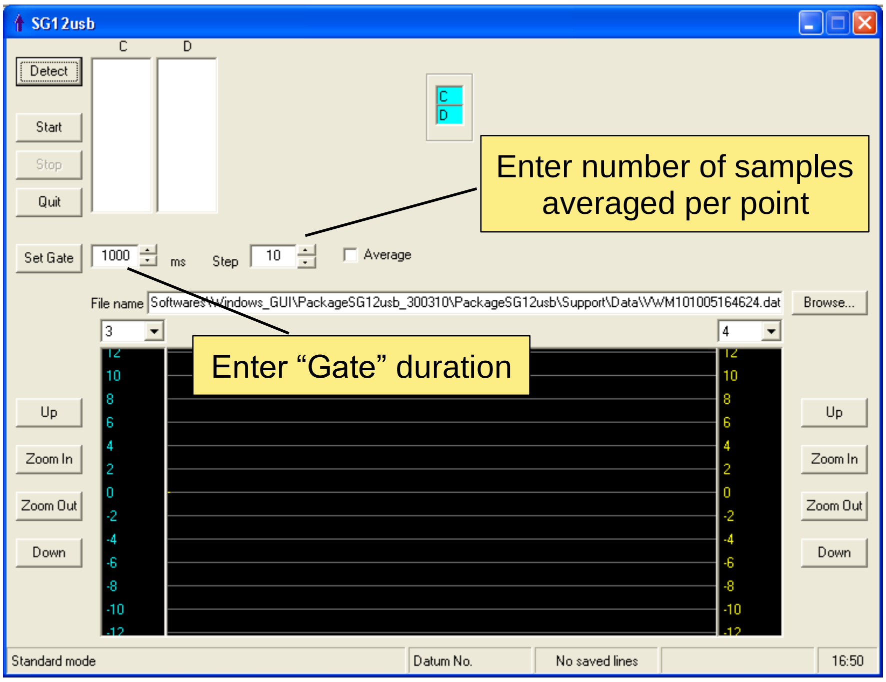
Insert CD, copy all files onto the PC hard disk.
Run the "StringGenerator 1.0" executable program:



The window hereafter appears:

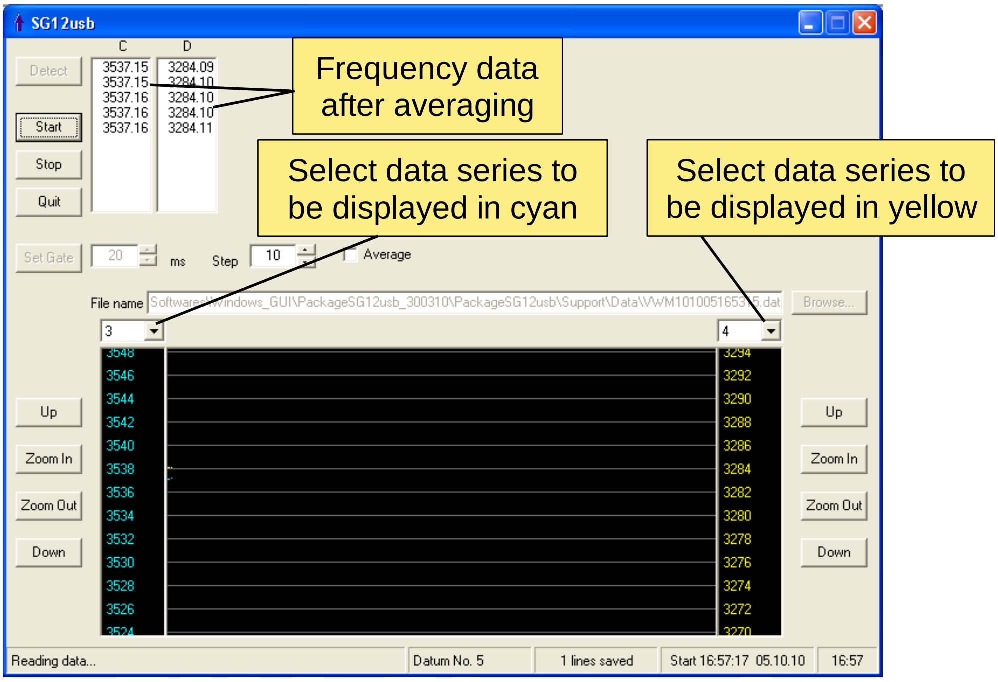


Click "Detect" button. The stations appear.



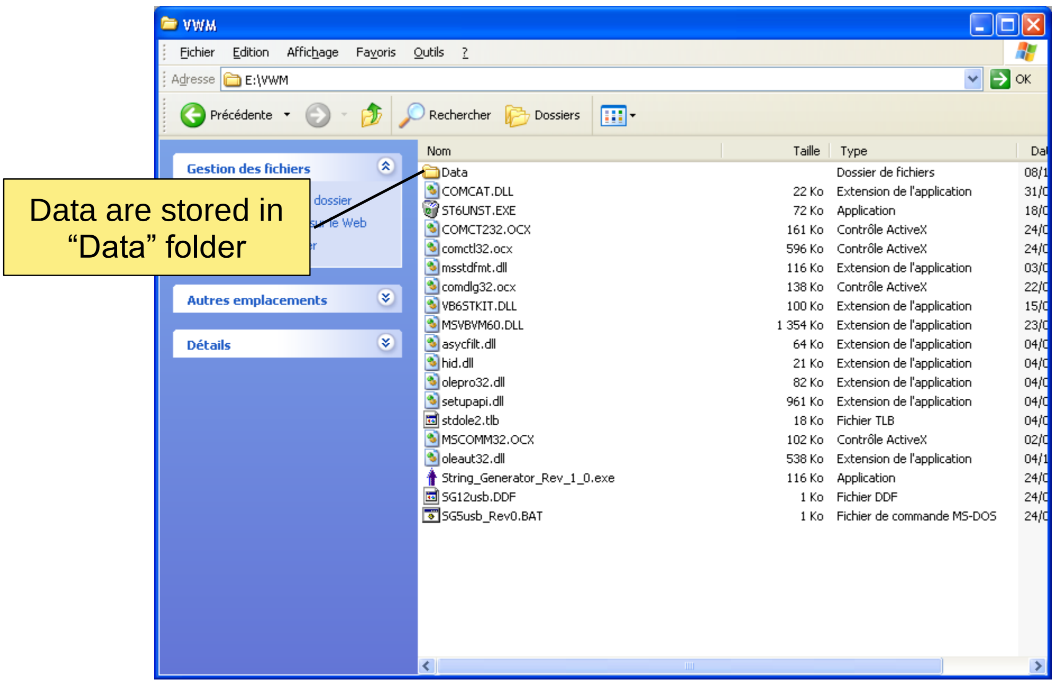
Note: the vibrating wire frequency is measured during the "Gate" duration. It can be set from 20 ms to 1200 ms. The Gate duration determines the measurement resolution. The longer the Gate is, the more accurate the measurement is, because more samples are taken into account.

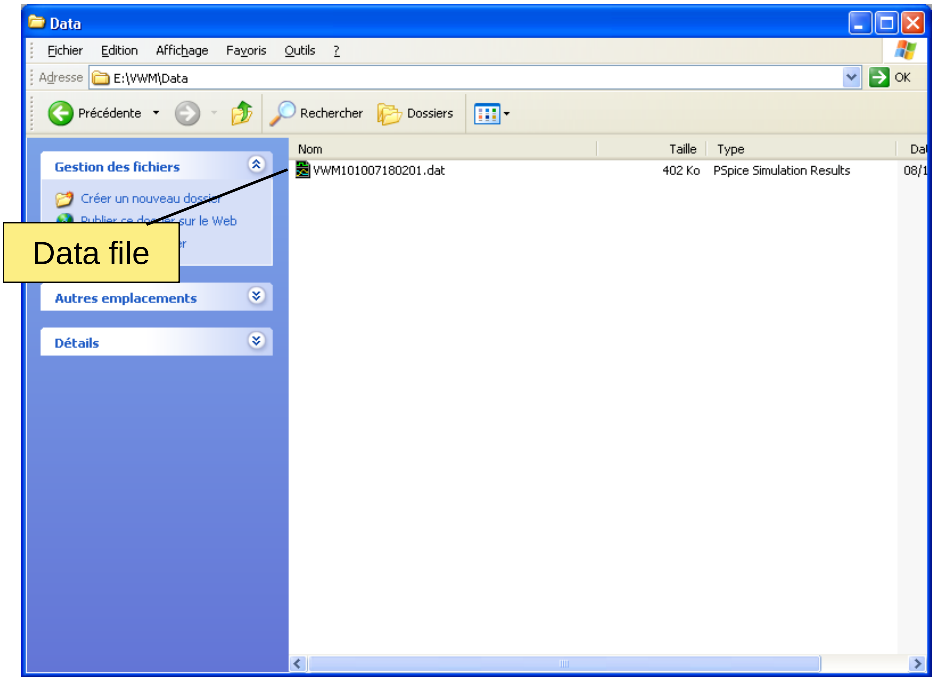
Click "Start" button to start the frequency measurement.



The vertical (frequency) scale adjusts dynamically.
It can be modified with the left and rights buttons: Up, Zoom In, Zoom Out and Dawn.

Time and Frequency measurement data are stored in a ".dat" file (VWMdatetime.dat) located in the "Data" folder in "StringGenerator 1.0"'s path. The data files can be further analyzed with a spreadsheet program or other grapher.




Data
Fichier
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Affichage
Favoris
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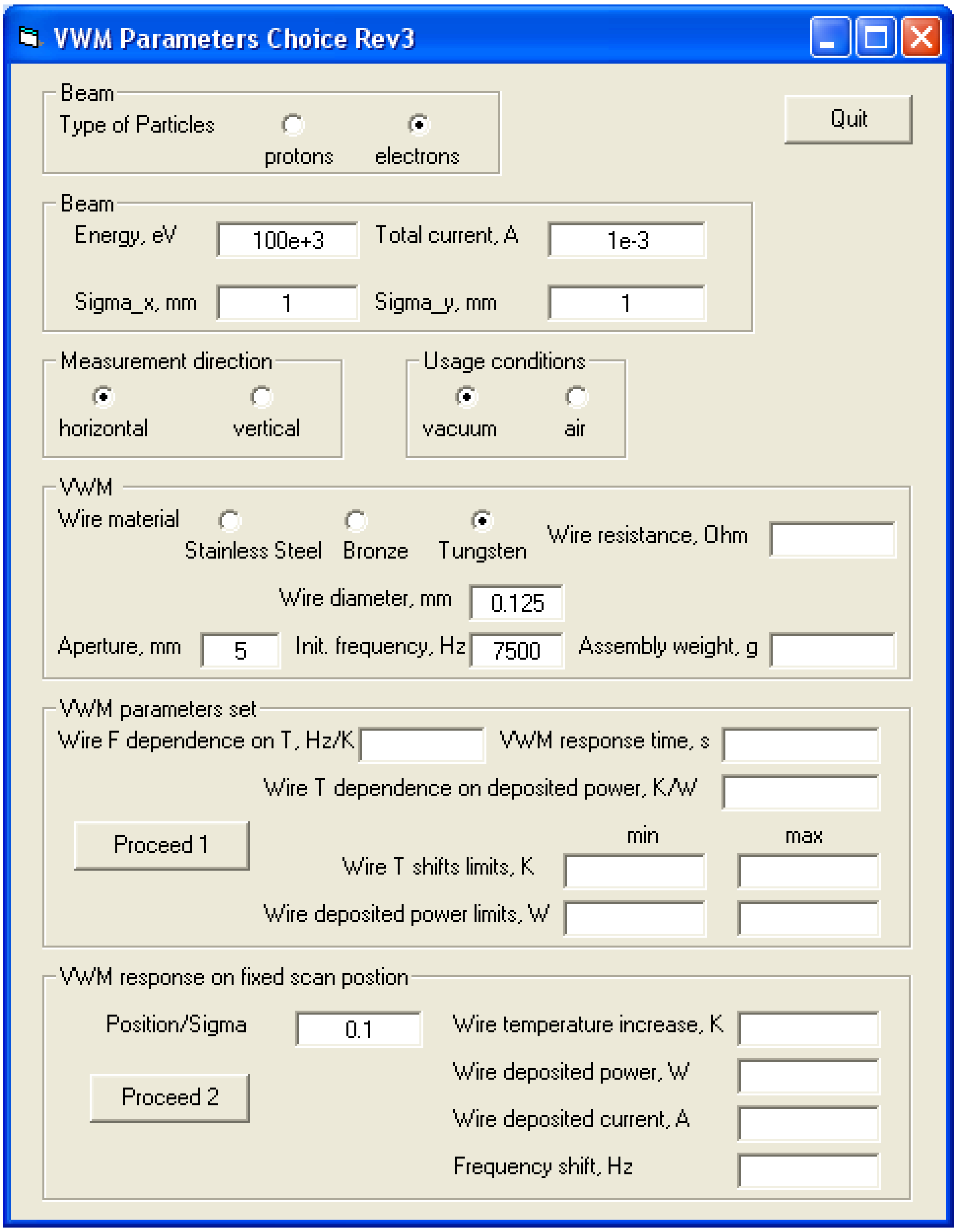
OK
Précédente
Rechercher
Dossiers
Gestion des fichiers
Créer un nouveau dossier
Autres emplacements
Détails
Nom
Taille
Type
VWM101007180201.dat
402 Ko
PSpice Simulation Results
Data file

SENSOR PARAMETER CHOICE

Choosing wire material, diameter and initial frequency

A program, VWM_choice_Rev.3.0, is available on the VWM deliverable CD, written in Visual Basic 6.0 and executable on a PC under Windows XP.... or later.
The program displays this screen:



The initial parameters must be entered:
Type of particles, Energy, Total current, beam Sigma-X, and Sigma-Y, Measured direction and Usage in Vacuum or Air.

Then variables can be entered and modified in search of the largest Frequency Shift at an entered beam Position/Sigma:

- Wire material: Stainless steel, Bronze or Tungsten. Wire resistance will be computed.
- Wire diameter: Available wires are 100um for Stainless steel and Tungsten, 125um for Bronze.
- Aperture of the sensor should be entered; total wire length will be computed.
- Initial frequency: Initially, 1000 Hz can be entered and refined later in search of optimum.

Note: Assembly weight is calculated; it is the weight to hang on the wire to obtain the entered frequency (See sensor assembly).

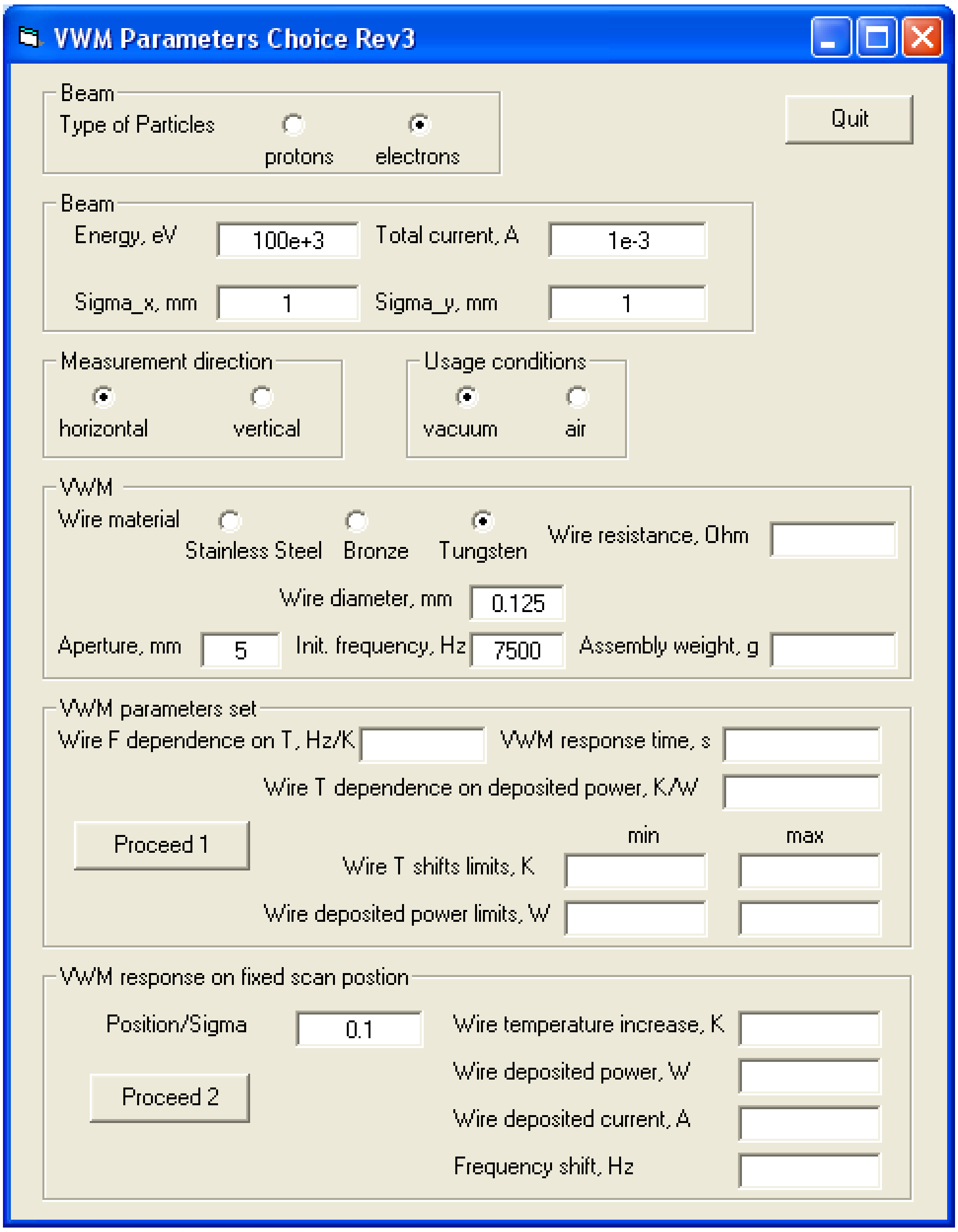
Then "Proceed 1" computes the wire frequency temperature dependence, time constant and operating limits.

"Proceed 2" computes for an entered Position/Sigma, the Temperature, Power, Current deposited and the resulting Frequency shift.
Now, iterating through the available Wire materials and initial frequency allows to find the optimum conditions.

The parameters to optimize depend on application:

- It may be resolution in which case Frequency shift is the measure of optimization.
- It may be response time, which is essentially wire material-dependent.

Program procedure



Initial frequency F_0 of the vibrating wire (second harmonic of natural oscillation) is defined by:

$$F_0 = \frac{1}{L}\sqrt{\sigma_0 / \rho}\,, \qquad (1)$$

where L is the wire length, σ_0 is the wire initial tension, ρ is the wire material density. Parameter σ_0 must not exceed the tensile strength of material. The corresponding weight needed for the VWM wire assembly and its resistance will appear after clicking on **Proceed 1** button.

Wire frequency **F dependence on** wire temperature **T** is defined by:

$$\Delta F / \Delta T = \frac{E\alpha F_0}{2\sigma_0}, \quad (2)$$

where α is the wire material coefficient of thermal expansion and E the modulus of elasticity of the wire material.

VWM response time is defined by three thermal processes: heat sink through the wire material, radiation losses and convection losses (in case of air).

Response time via thermal conductivity mechanism:

$$\tau_\lambda = c\rho/8/(\lambda/L^2), \quad (3)$$

where c is the specific heat, λ the is thermal conductivity coefficient.

Response time via radiation mechanism:

, (4)

where σ_{ST_B} is the Stefan–Boltzmann constant, T_0 is the wire initial temperatures (supposed to be room temperature), d is the wire diameter, is the emissivity of the wire surface (a measure of the ability of the wire surface to radiate energy).

Response time via convection mechanism in air

$$\tau_{CONV} = c\rho/8/(\alpha_{CONV}/2/d), \quad (5)$$

where α_{CONV} is the coefficient of convective losses.

Response time of the wire:

$$\tau_{RESP} = 1/(1/\tau_\lambda + 1/\tau_{RAD} + \delta/\tau_{CONV}), \quad (6)$$

where $\delta = 1$ in case of **air** and $\delta = 0$ in case of **vacuum**.

Wire temperature **T dependence on deposited power** is defined by:

$$\Delta T / \Delta Q = 1/2/\pi/d^2/l/(\lambda/l^2 + 2\varepsilon\sigma_{ST\_B}T_0^3 + \alpha_{CONV}/2/d). \quad (7)$$

Wire temperature **T shifts limits** are defined by the VWM electromechanical resonator characteristics:

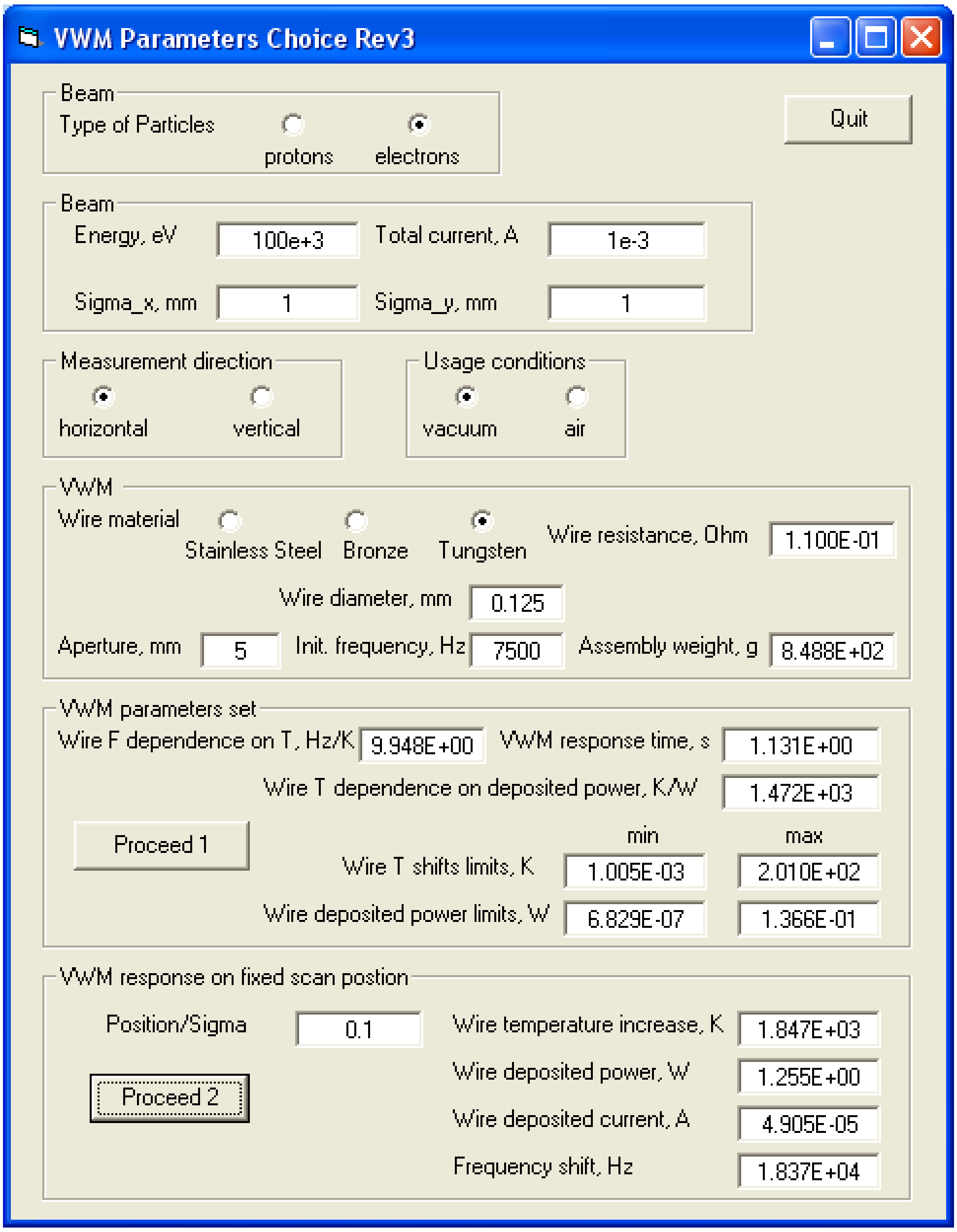
$\Delta F_{MIN} = 0.01 Hz$ (VWM resolution), (8)

$\Delta F_{MAX} = 2000 Hz$ when initial frequency $F_0 > 3000 Hz$ and (9a)

$\Delta F_{MAX} = (F_0 - 1000 Hz)$ when initial frequency $F_0 < 3000 Hz$. (9b)

Wire temperature shifts are calculated by using these values and (2).

Deposited power limits of the VWM are calculated by the same values, taking into account (2) and (7).



Position/Sigma is the position of the wire in units of beam sigma along the scan direction σ_{SCAN}, which is equal to σ_X (horizontal) or σ_Y (vertical) depending on the measurement direction:

$\sigma_{SCAN} = \sigma_X$ and $\sigma_{TRAN} = \sigma_Y$ (in the case of a **horizontal** measurement), (10a)

$\sigma_{SCAN} = \sigma_Y$ and $\sigma_{TRAN} = \sigma_X$ (in the case of a **vertical** measurement), (10b)

where σ_{TRAN} describes the beam distribution along the wire direction.

The current of particles penetrating the wire I_W is described by:

$$I_W = I_0 * K_A * \frac{d}{\sqrt{2\pi}\sigma_{SCAN}} * \exp(-x^2/2), \tag{11}$$

where I_0 is the beam **Total current**, x is the wire position in units of σ_{SCAN},

$$K_A = \int_{-A/2}^{+A/2} dz * \frac{1}{\sqrt{2\pi}\sigma_{TRAN}} * \exp(-z^2/2/\sigma_{TRAN}^2) \tag{12}$$

describes the limitation of the particles intersection with the wire caused by the limited VWM **Aperture** A. We assume that d is much smaller than σ_{SCAN}.

Heat transfer from the intersected particles with the wire depends on the particles type and energy, wire material and geometry. In this calculation we assume that the heat transfer is described by the ionization losses in the material, including a heat transfer coefficient k defining the part of losses really converted into heat:

$$\Delta Q = k * I_W * E_Z, \tag{13}$$

where $E_Z = \rho * E_{NORM}$.

The parameter E_{NORM} is calculated from Bethe-Bloch formula and *is about* $1.5 MeV * cm^2 / g$ for *3 GeV protons. This value weakly depends on particles* ***Energy*** E *and type when* $E \geq 1 Gev$.

ACKNOWLEDGEMENTS

VWM was developed on the basis of Suren Arutunian Vibrating Wire Scanner.
Dr. Arutunian received the Faraday Cup 2008 for this innovation.

Last revised: Saint Genis Pouilly, January 2020