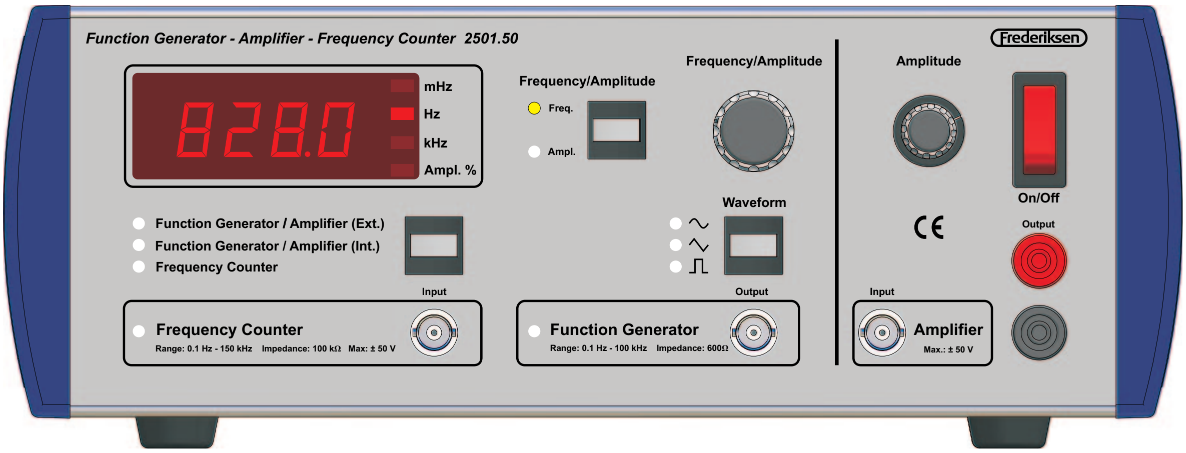
Function generator - Amplifier - Frequency Counter

03.01.11 Ae 2501.50



The apparatus comprises 3 different and independent units:

1. A function generator designed to generate sine, triangle and square waveforms.
2. A frequency counter.
3. An amplifier.

Ease of operation:
The front panel is purposely simplified - it has 5 control buttons and 4 input terminals. All buttons and terminals are equipped with head-line instructions thus that the use of them is explanatory. The LED's on the front panel indicate which mode etc. has been selected by means of the respective buttons.

Accuracy:
All functions have been digitalized. Frequency and amplitude are read out in every range as 4 digits to the large LED display, sufficient for most demanding measurements.

General description:
The function generator no. 2501.50 is microprocessor controlled, designed to generate sine, triangle and square waveforms.

Whenever the function generator is switched off all adjustments are kept in an "EEPROM". When switching on again then the stored adjustments are used and it is unnecessary to adjust once more.

The function generator no. 2501.50 has RS232 interface facilities. All functions of the generator unit including adjustments of frequency and amplitude can be controlled through the RS232 interface.

The power amplifier is protected against short circuit. At any possible overload the apparatus must beswitched off and the load is to be removed from the out put before restarting the apparatus.

A/S Søren Frederiksen, Ølgod
Viaduktvej 35 · DK-6870 Ølgod
Tel. +45 7524 4966
Fax +45 7524 6282
info@frederiksen.eu
www.frederiksen.eu
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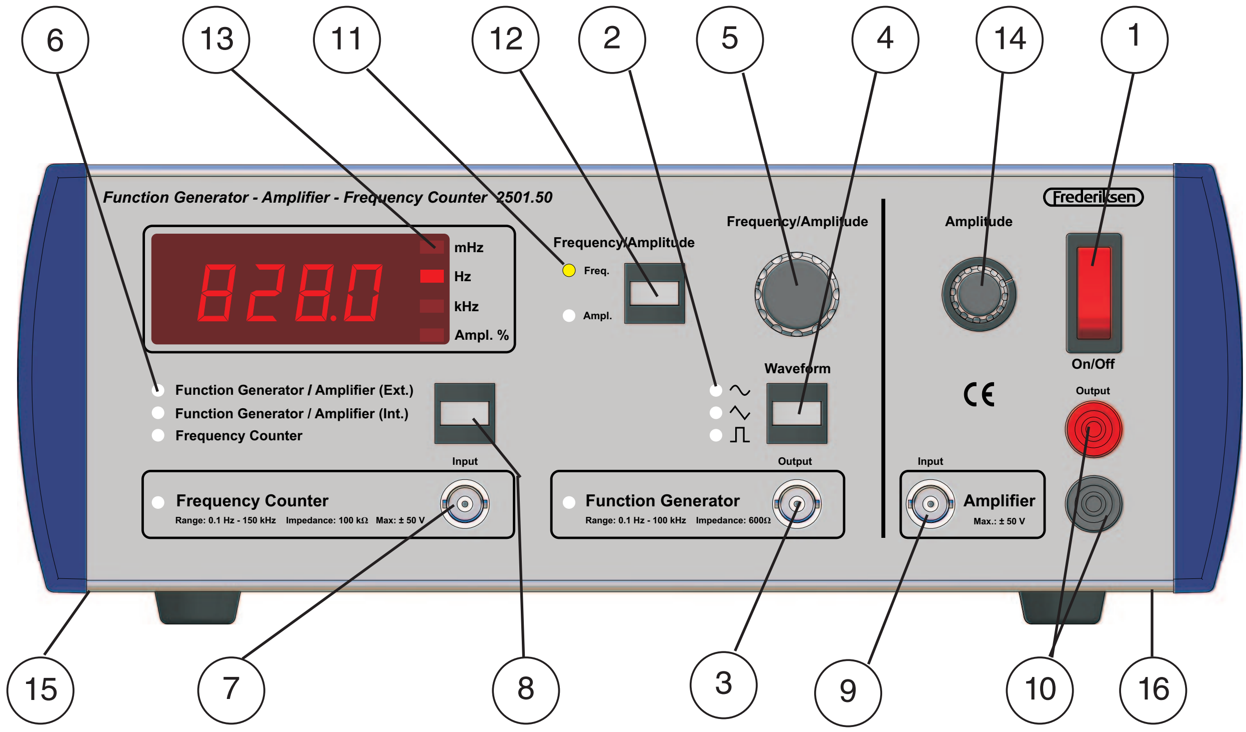


Operation levers:

Pos. 1: Power ON/OFF button, illuminates ON position.

Pos. 2: LED is indicating the selected waveform output.

Pos. 3: Function generator output BNC-terminal.

Pos. 4: Pushbutton for selecting waveform.

Pos. 5: Digital encoder for adjusting frequency and amplitude depending on the adjust-ment of

Pos. 6: LED indicating the main function of 2501.50. The 3 possible functions are:

a: Function Generator/Amplifier (Ext.): The Function Generator's output is only applied to the Output BNC pos. 3.

b: Function Generator/Amplifier (Int.): The Function Generator output is internally connected to the DC Power Amplifier and the power amplifiers Input terminal pos. 9 is disconnected.

c: Frequency Counter: The frequency of a signal applied to the BNC terminal pos. 7 is read out to the display.

Pos. 7: BNC input terminal for frequency counting or input terminal for FM modulation.

Pos. 8: Pushbutton for selecting of the apparatus main function, The position selected is automatically the start position next time the apparatus is switched on.

Pos. 9: BNC terminal for amplification of external signals.

Pos.10: Output for power amplifier, (Bananater-minals).

Pos.11: LED indicating read outs of frequency or amplitude to the display.

Pos.12: Pushbutton for selecting frequency or amplitude. However, inactive when the selector pos. 8 is set to the Frequen-cy Counter mode.

Pos.13: Light bars indicating the displayed unit of frequency or amplitude.

Pos.14: Control lever for adjusting the Power Amplifier.

Pos.15: RS232C serial interface port.

Pos.16: Mains inlet, with fuse holder.

Operation:

The function generator is easy to operate and adjust. Whenever a change in amplitude or frequency is desired, simply activate the pushbutton pos.12 to change display and adjust the digital encoder pos. 5. The digital encoder is "speed-sensitive" i.e. if you make a fast turn a large step is taken, and if you make a slow turn only a small step is taken.

Measuring the frequency of an external signal is possible if the external signal is applied to the terminal marked "Input" pos. 7. Select the Frequency Counter mode by means of the pushbutton pos. 8. If the unknown frequency measured is inside the given limits it will be displayed, and if not the display will read "Err". The display will also read "Err" after 15 seconds if the Frequency Counter mode has been chosen and no signal is applied to the "Input" pos. 7.

The Input pos. 7 may be used as modulation input e.g. to demonstrate FM modulation. As long as the output frequency pos. 3 is within the limits of a decade, the frequency will deviate according to input amplitude and frequency. If the input signal is both positive and negative the output frequency swing is maximised if the centre frequency is set in the middle of a decade (e.g. 5 kHz). If the input signal is solely positive the maximum deviation is achieved by setting the centre frequency in the lower part of the decade (e.g. 1.1 kHz).

An extremely useful feature of this apparatus is the ability to store the settings of frequency, amplitude and mode when the apparatus is switched off. When switched on again the settings will be restored hence readjusting etc. is unnecessary.

The Power Amplifier (DC-coupled) is capable of amplifying a signal applied to the Input terminal. Adjusting the amplification factor is done by means of the control knob pos. 14. Setting mode selection button pos. 8 on to the Function Generator/Amplifier(Ext.) mode, then the Input terminal pos. 9 is disconnected from the signal generator and the Power amplifier can now be used separately. Although the Power Amplifier is protected against overload we recommend following precaution to be taken: Always make sure that the amplification control pos. 14 is set to zero - turn it fully counterclockwise - before you start using the apparatus.

Serial interface:

The apparatus serial port is connected to the computer's serial input, with cable no. 1123.20. The data format is 8 bit ASCII, no parity, 1 start bit and 1 stop bit. The following commands are accepted by the function generator written in either upper or lowercase letters.A command has to be followed by line feed (LF).

A: Read or set the amplitude. Using this command alone, the actual amplitude % is returned. If a numerical value is indicated, (e.g. A38) the function generator is set at 38 % amplitude.

B: Read or set the baud rate. When this command is used alone, then the actual baud rate returned. If this command is used together with a numerical value e.g. B300 then the baud rate is set to 300.

D: Display frequency or amplitude. Using this command alone, 1 or 2 is returned depending on whether the display is set to monitor frequency or amplitude. Using D plus a number (1 or 2) then one of the following two functions can be chosen.

d1: frequency

d2: amplitude

F: Read or set frequency. Using this command alone, then the actual frequency is returned. Using "F" plus a number, the frequency is set to the frequency in question.

G: Read or set mode. Using the command alone, then the actual function is returned. Using command G plus a number, (1, 2 or 3), then the function generator is set accordingly:

g1: Function Generator/Amplifier (Ext.)
g2: Function Generator/Amplifier (Int.)
g3: Frequency Counter

L: Restore standard settings. The standard parameters are: 1200 baud, monitor frequency, sine, 50 % amplitude, 1.000 kHz, Function generator/ Amplifier (Int.) and no messages.

M: Messages turned on (default off). Additional information will be returned when using interface commands.

N: Messages turned off (default).

V: Version number is returned.

W: Read or set waveform. Using W alone, the waveform is returned. Using "W" plus a number (1, 2 or 3) the waveform is changed accordingly :

w1: sine
w2: triangle
w3: square

?: Returns a help-menu to the monitor.

Standing waves in an air column

When sound waves are reflected at the ends of a tube, *resonances* occur at certain frequencies, giving rise to standing waves. This happens if the sound wave after two reflections is in phase with the original wave, resulting in an increased sound level at this particular frequency.
Surprising as it seems, sound is reflected not only at a closed end but also at an open one.

As the air cannot move into or out of a solid, pressure variations build up at a closed end. On the other hand, the air molecules are free to vibrate at the open end of a tube, resulting in minimal pressure variations.
The microphone used in these experiments measures the sound as variations in the air *pressure,* not the *velocity.* We will therefore concentrate on pressure variations in this treatment.

To the right some examples of resonances are drawn schematically.
Places with a **minimum** variation in sound pressure (e.g. at the open ends in the third drawing) are called **nodes,** marked N.
Places with a **maximum** variation in sound pressure (e.g. at the closed ends in the first drawing) are called **anti-nodes,** marked A.
Notice, that the distance between to neighboring nodes (or two anti-nodes) is one half of the wavelength λ.

As can be observed from these drawings, the length of the tube L and the wavelength λ cannot be chosen arbitrarily. They have to fulfill the *resonance condition.*

For a tube that is open or closed at *both* ends the resonance condition takes the form

$$L = n \cdot \frac{\lambda}{2}$$

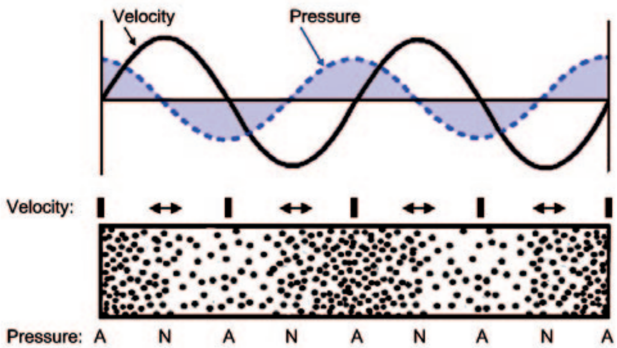
– where n is an integer and L is the effective length of the tube.
For a tube with one open and one closed end we have instead

$$L = n \cdot \frac{\lambda}{2} + \frac{\lambda}{4}$$

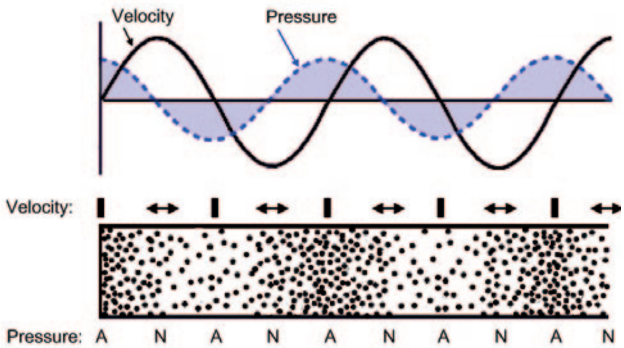
When open ends are involved, L is a little longer than the mechanical length. A node at an open end is positioned a little bit outside of the opening.
In any case the distance between two adjacent nodes (*or* anti-nodes) is

$$\Delta L = \frac{\lambda}{2}$$

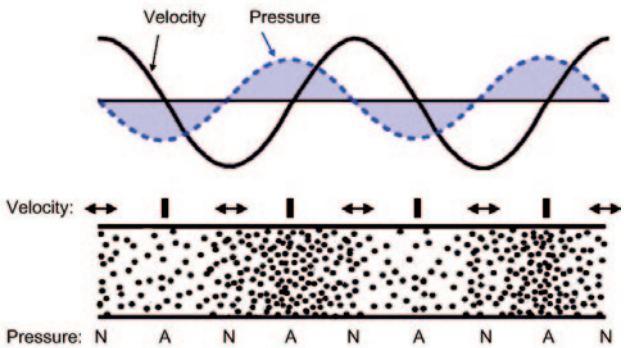
Closed ends



One end open, one closed



Open ends



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The speed of sound in a gas

Purpose
In this experiment we measure the speed of sound in a gas.
CO_2 is suggested – ordinary air works just as well.

Theory
Please refer to separate page.

Procedure
If the piston is in position in the tube, remove it. Put on both of the end caps. Connect the microphone and the loudspeaker as shown.
Insert the microphone probe with only the tip through the end opposite the loudspeaker.
Adjust the frequency f to approximately 100 Hz and check, that the meter is giving a reading.

Now the resonance pipe must be filled with CO_2. Let the gas flow rather slowly to avoid cooling the apparatus too much. Wait a few minutes after filling the pipe to allow it to go back to room temperature.

Adjust the frequency to a resonance (a maximum reading) and write it down. The lowest possible resonance frequency should occur at around 150 Hz in CO_2 (190 Hz in air). This is known as the fundamental or first harmonic frequency. At this frequency, the length of the tube is $\lambda/2$.

Now double the frequency and search for the resonance of the second harmonic frequency (length of tube equals λ). Go on with third, fourth … n'th harmonic. Write down the exact frequency for each resonance. For every harmonic, the wavelength can be found from the resonance condition.
The velocity of sound can be found when wavelength and frequency are known:

$$v = f \cdot \lambda$$

Compare your results with the theoretical expression for an ideal gas:

$$v = \sqrt{\frac{c_p \cdot R \cdot T}{c_v \cdot M}}$$

– where R is the gas constant, T is the absolute temperature, c_p and c_v are the specific heat at constant pressure resp. constant volume, M is the molar mass.
(In case of a mixture of gasses – e.g. air – use the weighed averages for c_p, c_v and M.)

Required Equipment

2480.10 Resonance pipe	1.00 Pcs
2515.50 Microphone probe	1.00 Pcs
2501.50 Function generator	1.00 Pcs
2515.60 Power supply	1.00 Pcs
3862.15 Digital voltmeter (an oscilloscope may also be used)	1.00 Pcs
Carbon dioxide	

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Transverse waves on a string

The velocity v of transverse waves on a string depends on the tension F of the string as well as its specific mass ρ i.e. its mass per unit length. The purpose of this experiment is to verify the following relation:

$$v = \sqrt{\frac{F}{\rho}} \qquad (1)$$

We therefore need an independent way to measure the velocity. This is done by finding a resonance frequency f of the string and the corresponding wavelength λ from which we can find v:

$$v = f \cdot \lambda \qquad (2)$$

The string is tensioned by a weight m_W pulling with the force $F = m_W \cdot g$. The specific mass is found from the mass m and the length x of the string: $\rho = m/x$

Procedure

Prepare approximately 1.5 m of 3 different nylon cords and find the specific mass of each. Write down the results in a copy of table **A** below. For each string, a number of resonances should be found for three different masses m_W. For every combination of string and weight, you should start by finding the fundamental resonance frequency where the length of the string equals $\lambda/2$. Continue with two of the harmonics. In the picture below, the string is resonating on the third harmonic, and $L = 3 \cdot \lambda/2$ from which λ can be found. Write down the results in a large table (27 rows) like table **B** below.

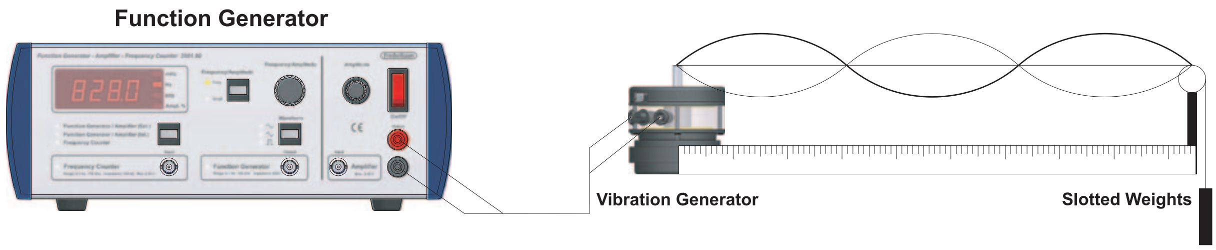


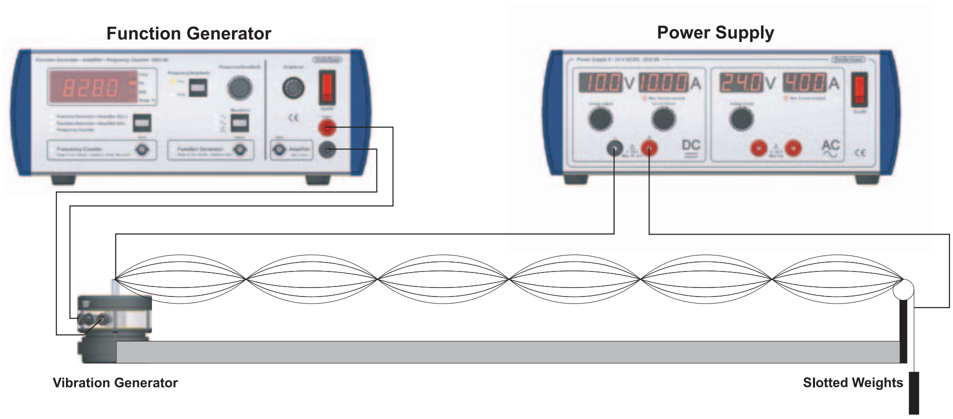
Table **A** String #	mass m kg	length x m	specific mass ρ kg/m
#1			
#2			
#3			

Table **B** String #	*mass* m_W kg	tension $F = m_W \cdot g$ N	frequency f s^{-1}	wavelength λ m	velocity (1) $v = f \cdot \lambda$ m/s	velocity (2) $v = \sqrt{F/\rho}$ m/s

The two last columns should show the same values – apart from experimental uncertainties. A way to test the over-all agreement is to plot velocity (2) against velocity (1). The points should lie close to a straight line with inclination equal to 1.

Filament cord:

This experiment is extremely well suited for demonstration, and has been included because it presents itself very nicely to an audience. The demonstration has the best effect when performed in a darkened room. The idea is simply to use a metal cord to perform standings waves, while the cord is slightly glowing because an electric current has been applied.



Experiment set-up:

A piece of ordinary metal wire, length approx. 1.3 m may be used. Applied a current of 7 A the cord will glow in a suitable cherry-red colour. Attach a mass of 100 g to the filament cord and let the Function Generator drive the Vibration Generator at a frequency of approx. 45 Hz. The filament cord will now oscillate in a pattern with 5-6 nodes. The filament cord will glow in a cherry-red colour at the node points while the wave bows will turn black because cooled by the air.

Applying current to the cord can be done simply by means of e.g. alligator clips. A metallic pulley is most expedient for establishing contact (beware of acrylic pulleys they may be destroyed by the heat!). Type of cord, load and frequency may be varied as you please.

Technical specification:

Power voltage :
230 volt AC +6%/-10% - 50/60 Hz.

Display:
4 digits LED.

Power consumption:
13 Watt at idling and 60 Watt at full load.

Fuse:
2 x 1 AT.

Dimensions:
297 x 225 x 118 mm

Weight:
3,7 kg

Signal:
Frequency range:
0,1 Hz to 100 kHz.

Output signals:
Sine, triangle and square.

Output power, sine:
0 to 20 voltpp.

Output impedance:
600 Ohm.

Distortion:
Normally 0,5% THD at 1 kHz sine.

Amplifier:

Frequency range:

DC to 50 kHz at -3dB.

Output power:
10 Watt RMS at 4 ohm.

Output level:
±10 voltpp.

Signal/noice level:
> 92 dB.

Input impedance:
10 k ohm.

Amplification factor, max.:
10

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