1607

INSTRUCTIONS AND APPLICATIONS

Frequency and Distortion Measuring Bridge Type 1607

A blocking network for measurement of frequencies and distortions in the audio frequency band.

BRÜEL & KJÆR

NÆRUM, DENMARK. Teleph.: 80 05 00. Cable: BRUKJA. Telex: 5316. COPENHAGEN

BB 1607 . 0300032

Frequency and Distortion Measuring Bridge

Type 1607

Reprint october 1967

Contents

Description

The Frequency and Distortion Measuring Bridge Type 1607 is an instrument designed for frequency and distortion measurements within the frequency range 20—20000 c/s and provides facilities for the selective rejection of any frequency within this range.

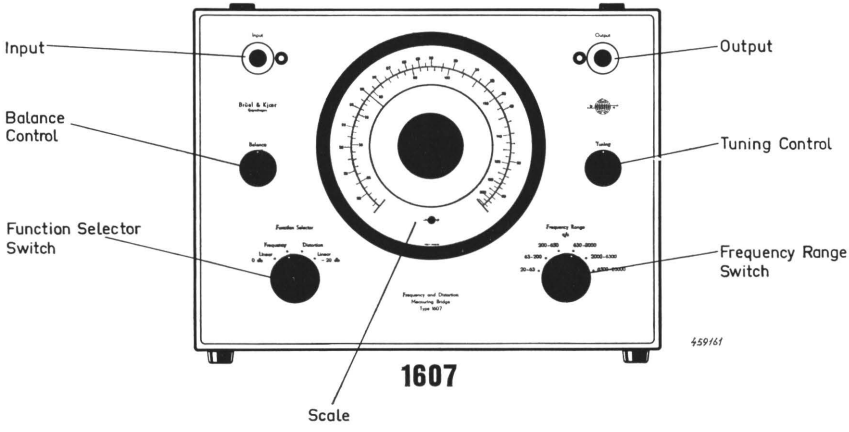

Fig. 1. The front panel layout of the 1607 showing identification of the controls.

When it is used in conjunction with an indicating device such as an RMS vacuum tube voltmeter, the 1607 makes it possible to measure total harmonic distortion down to 0.1 % in a one-reading operation. When used with a suitable frequency analyzer distortions lower than 0.01 % can be measured. Basically the instrument consists of a parallel-T resistance capacity network with continuously variable resistance components. The capacitors of the

network, which are variable in switched steps, are used to provide 6 subdivisions of the frequency range. The tuning scale on the front panel of the instrument is 280° and marked 20—63 and 63—200. When the scale is used in conjunction with the FREQUENCY RANGE switch it will provide frequency measurement readings within the following ranges to an accuracy of better than 1 % of the scale reading:

1. 20—63 c/s
2. 63—200 c/s
3. 200—630 c/s
4. 630—2ooo c/s
5. 2ooo—6300 c/s
6. 6300—20ooo c/s

In addition to the symmetrical frequency rejection characteristic a compensating network for distortion measurements can be switched in giving a constant attenuation of 20 dB ± 1 dB within a frequency range extending from the 2nd to the 7th harmonic of the frequency to which the network is tuned. This is very convenient when making one-reading distortion

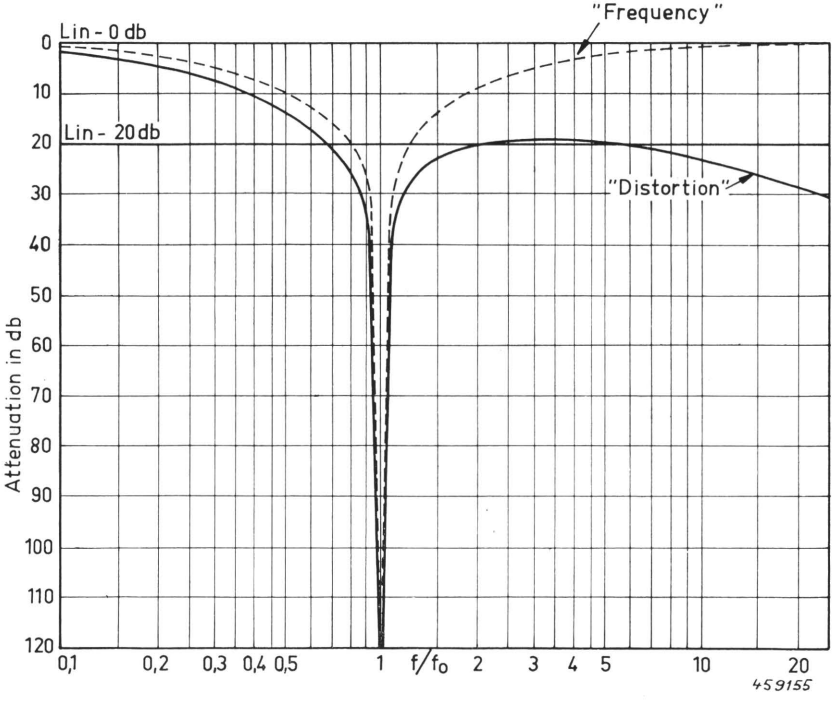

Fig. 2. The frequency characteristics of the filter network showing the response curves for the various settings of the FUNCTION SELECTOR switch.

measurements with the 1607 as the symmetrical frequency characteristic of the filter network will cause a varying degree of attenuation of the harmonics. (See Fig. 2).

For the purposes of comparison a setting marked "Linear — 20 dB" of the FUNCTION SELECTOR switch gives on over-all frequency attenuation of 20 dB. In this position the parallel-T network is not in use.

Curves showing the frequency characteristics of the filter network for the different settings of the FUNCTION SELECTOR switch are shown in Fig. 2, while Fig. 3 shows an enlarged portion of Fig. 2 for comparison of the response curves for the "Distortion" and "Frequency" settings of the FUNCTION SELECTOR switch.

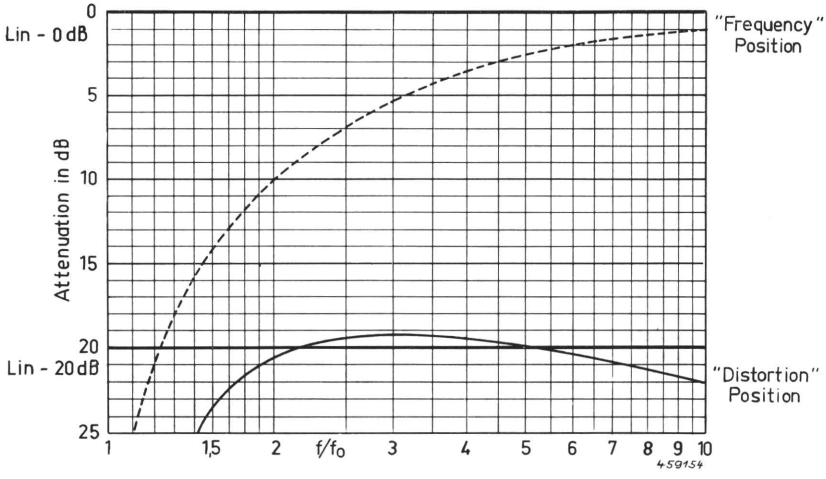

Fig. 3. An enlarged portion of Fig. 2 showing a comparison in the filter response between the "Frequency" and "Distortion" settings of the FUNCTION SELECTOR switch.

The potentiometers of the parallel-T network are ganged and accurately adjusted so that the attenuation at any setting of the frequency scale is at least 40 dB. To obtain a greater attenuation the adjustment of an additional potentiometer in series with one of the parallel-T circuit potentiometers can be made with use of the control marked BALANCE. By successive adjustments of the TUNING and BALANCE controls for maximum attenuation, (minimum deflection or sound output on the indicating device), the frequency to which the network is tuned will be rejected by more than 80 dB with reference to position "Linear 0 dB".

AC and DC voltages connected to the input must not exceed 100 volts. The filter circuits are blocked for DC voltages.

The input impedance of the bridge ranges between 5.5 kΩ and 18 kΩ depending upon the setting of the frequency scale and the FUNCTION SELECTOR switch. The attenuation values stated above are only valid provided that the impedance of the signal source is small when compared with 5 kΩ. The input impedance of the instrument to which the output of the bridge is connected should be not less than 100 kΩ.

In the interest of correct matching and where it is required to offer the circuit under test a high impedance, the 1607 has been designed for direct connection to the FILTER INPUT and FILTER OUTPUT terminals of the B & K Microphone Amplifier Type 2604. When used in this manner the correct matching conditions for the 1607 are provided and the high impedance input of the 2604 approximately 1.1 MΩ in parallel with 30 $\mu\mu$F, is offered to the circuit under test. Additionally, the complete frequency range of 1607 can be utilized, as when measuring distortion at 20ooo c/s the indicating device should be able to measure the 7th harmonic, i.e. 140 kc/s.

Operation

As the instrument contains only passive networks, no power supply is necessary.

Frequency Measurements.

A vacuum tube voltmeter, or another type of indicator having input impedance of 100 kΩ or more should preferably be used for indication of the output voltage of the 1607.

To measure a frequency, set up the instruments as shown in Fig. 4 and proceed as follows:

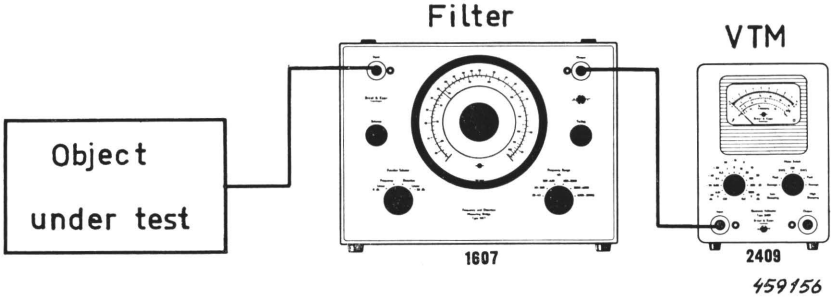

Fig. 4. Arrangement for frequency measurement.

1. Set FUNCTION SELECTOR switch to "Frequency".
2. Adjust TUNING and BALANCE controls until a minimum deflection is indicated.
3. Read the frequency on the scale in conjunction with the range indicated by the setting of the FREQUENCY RANGE switch.

One-Reading Distortion Measurements.

The Type 1607 Bridge is most suitable for use in harmonic distortion measurements as the fundamental frequency can be very accurately tuned out.

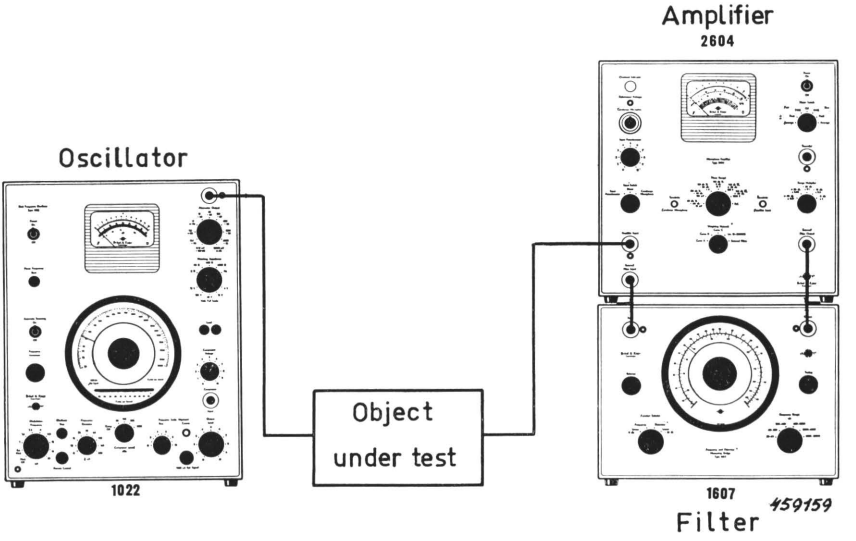

Fig. 5. Arrangement for distortion measurements using the 2604 Microphone Amplifier as an indicating device.

To make full use of the Distortion Bridge in harmonic distortion measurements it is imperative that a suitable amplifier is used between the output of the 1607 and the indicating device. In order to meet the requirements of correct matching and linearity the use of the B & K Microphone Amplifier Type 2604, which includes a suitable indicating device in the form of a vacuum tube voltmeter, is strongly recommended. This amplifier provides facilities for true RMS indication, low distortion of the input amplifier (lower than o.1 %) and has a linear characteristic up to 200ooo c/s which is sufficient for the Distortion Bridge. A suitable arrangement for distortion measurements down to o.1 % is shown in Fig. 5.

To use the arrangement shown in Fig. 5 set up as illustrated and proceed as follows:

Set the controls on the Amplifier 2604 as follows:

1. INPUT POTENTIOMETER: Fully clockwise.
2. INPUT SWITCH to: "Input Potentiometer".
3. WEIGHTING NETWORK switch to: "Ext. Filter".
4. METER RANGE to: "1ooo V".
5. RANGE MULTIPLIER to: "× 1".
6. METER SWITCH to: "RMS (Fast)".

To set up the 1607 in conjunction with the 2604 Amplifier for distortion measurements proceed as follows:

7. FUNCTION SELECTOR to: "Linear — 20 dB".
8. FREQUENCY RANGE switch to a range which includes the fundamental frequency of the signal to be measured.
9. Turn the METER RANGE switch on the 2604 counter-clockwise until the meter shows a slight over-load then regulate the meter to full scale deflection by means of the control marked INPUT POTENTIOMETER.
10. Set the 1607 FUNCTION SELECTOR to "Distortion" and adjust for minimum deflection by the controls TUNING and BALANCE. If further sensitivity is required on the 2604 turn RANGE-MULTIPLIER switch counter-clockwise until a suitable reading is obtained.
    (Note: When using the 2604 do not readjust the METER RANGE switch after adjustment instruction 9 has been made as this may cause overloading of the amplifier).
11. The harmonic distortion factor can now be read off directly on the scale of the 2604 in conjunction with the setting of RANGE MULTIPLIER switch.

    The distortion factor ranges covered by the setting of the RANGE MULTIPLIER switch are as follows:

RANGE MULTIPLIER setting	Full scale deflection corresponds to.
"× 1"	100 % distortion
"× o.3"	31.6 % »
"× o.1"	10 % »
"× o.03"	3.16 % »
"× o.01"	1 % »

It should be noted that when making total harmonic distortion measurements in this manner consideration should be given to the fact that only the harmonics from the 2nd to the 7th can be measured with a reasonable degree of accuracy. Further, that any possible frequencies present which are lower than the rejected frequency (for example: hum) contribute to the output signal and can, therefore, give an erroneous indication of the actual harmonic distortion present. If the signal under examination is known to or found to contain a hum component which influences the distortion measurements, it

will be necessary to filter it out if an accurate measurement of the distortion is desired. Under the heading "Distortion Analysis" an arrangement is described employing the B & K Frequency Analyzers Type 2107 or 2112. This arrangement will eleminate hum effects and is strongly recommended where hum is particularly troublesome.
A further arrangement for distortion measurements is shown in Fig. 6 and consists of the Bridge Type 1607 and the B & K Electronic Voltmeter Type 2409.

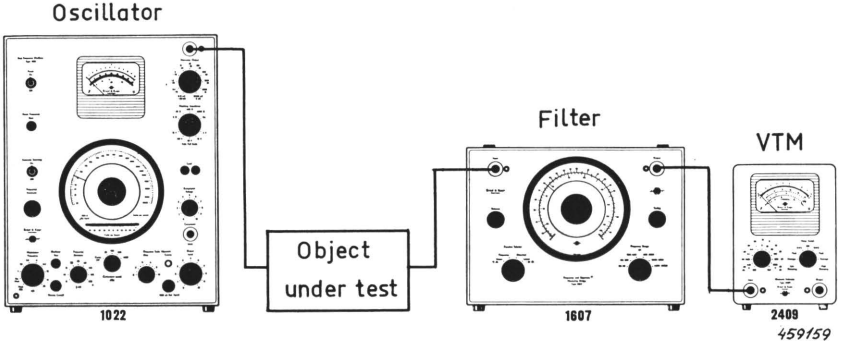

Fig. 6. Alternative arrangement for distortion measurements using the VTVM 2409 as an indicating device in conjunction with the 1607 and the Oscillator 1014.

When using the set-up shown in Fig. 6 distortion factors below o.1 % can be measured. The procedure is as follows:
The FUNCTION SELECTOR switch of the 1607 is set to "Linear — 20 dB", and the input attenuator of the Electronic Voltmeter is adjusted to give a suitable deflection. The FUNCTION SELECTOR switch is then turned to the "Distortion" setting and a minimum deflection is obtained on the Voltmeter by adjustment of its input attenuator and by tuning the filter controls of the 1607 as previously explained.
The percentage of the harmonic distortion may then be found from the relationship:

$$d_{tot} = \frac{V_2}{V_1} \times 100\ \%$$

where: V_1 is the deflection first obtained and V_2 is the minimum deflection of the Voltmeter.
If the Bridge is used in conjunction with a vacuum tube voltmeter of another manufacture than the one mentioned, the following recommendations should be observed:

1. It must show RMS indication.
2. The input impedance must be higher than 100 kΩ.

3. The frequency range of the instrument should be linear up to the frequency of the 7th harmonic of the highest fundamental frequency at which distortion measurements are to be made.

Distortion Analysis.

Where distortion measurements lower than 0.01 % are required, and where hum is troublesome, it is necessary to make harmonic analysis of the signal. This can be done by employing an audio frequency analyzer and a suitable indicating device. Fig. 7 shows an arrangement using the B & K Frequency Analyzer Type 2107 which is provided with an indicating meter. The B & K AF Spectrometer Type 2112 may also be used instead of the Type 2107 Analyzer. It should be borne in mind that whereas the pass band of the 2107 can be varied from 6 % to 29 %, that of the Spectrometer is fixed at ⅓ or ¼ octave.

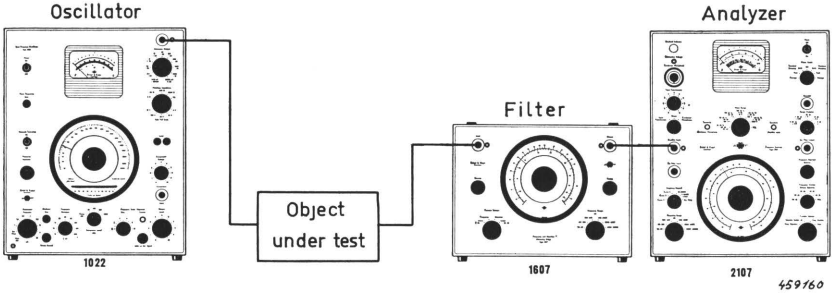

Fig. 7. Arrangement for the analysis of individual harmonic components. This method may be adapted where hum or other unwanted voltages otherwise influence the measurements.

To use the arrangement shown in Fig. 7 set up as illustrated and proceed as follows:

1. On 1607, set FUNCTION SWITCH to "Linear — 20 dB".
2. Set FREQUENCY RANGE switch to a range which includes the fundamental frequency.
3. On 2107, set INPUT SWITCH to "Input Potentiometer", WEIGHTING NETWORK to "20—40ooo c/s" and FUNCTION SELECTOR to "Selective Section Off" and METER SWITCH to "RMS", "Fast".
4. Turn METER RANGE, RANGE MULTIPLIER and INPUT POTENTIOMETER until full scale deflection on the meter is obtained.
5. Set the FUNCTION SELECTOR switch on the 1607 to "Distortion" and tune for maximum rejection of the fundamental frequency, i.e. minimum deflection on indicating meter. The METER RANGE of the 2107 may have

to be adjusted during this operation to keep a deflection on the meter.

6. Set OCTAVE SELECTIVITY to "35 dB" and FUNCTION SELECTOR to "Frequency Analysis".
7. Turn the FREQUENCY RANGE switch on Type 2107 to a range covering the harmonic frequency to be measured.
8. With the Frequency Tuning knob on Type 2107 set the pointer of the main scale to the frequency of the selected harmonic and carefully fine-adjust for a maximum deflection on the meter. If needed increase sensitivity by RANGE MULTIPLIER.
9. Set OCTAVE SELECTIVITY to a higher value if necessary.

It is now possible to calculate the harmonic distortion of the component measured as a percentage of the fundamental from:

$$d = \sqrt{\frac{a_2^2 + a_3^2 + a_4^2 \ldots + a_n^2}{a_1^2 + a_2^2 + a_3^2 \ldots + a_n^2}} \times 100\ \%$$

$$\cong \frac{\sqrt{a_2^2 + a_3^2 + a_4^2 \ldots + a_n^2}}{a_1} \times 100\ \%$$

where: a_1 = amplitude of fundamental, a_2 = amplitude of second harmonic. and so on.

Specification

Frequency Ranges:

20— 63 c/s	63— 200 c/s
200— 630 c/s	630— 2ooo c/s
2ooo-–6300 c/s	6300—20ooo c/s.

Frequency Scale Accuracy: Better than 1 %.

Scales: Easily read, 280°, calibrated 20—63 and 63—200 with suitable overlaps.

Response of Attenuator: In the "Distortion" position the attenuation of the higher pass-band is 20 dB ± 1 dB from the 2nd to the 7th harmonic of the rejected frequency.

Attenuation of the Rejected Frequency: Better than 80 dB, re. position "Linear, 0 dB".

Impedances:
Input: Between 5.5—18 kΩ depending on scale setting.
Output: Dependent upon control settings, but should be connected to an external impedance of not less than 100 kΩ.

Maximum Permissable Input Voltage: 100 V AC and DC.

Distortion Measurement Percentage Range: When using a non-selective amplifier and indicating device, to approximately o.1 %.
When using the B & K Analyzer Type 2107 or A.F. Spectrometer Type 2112 to better than o.01 %.

Dimensions	Depth	Length	Height
Centimetres	22	40	30
Inches	9	16	12
Weight	8.5 kgs		18.5 lbs.

ORBOE PRINT . COPENHAGEN . DENMARK

November 1967