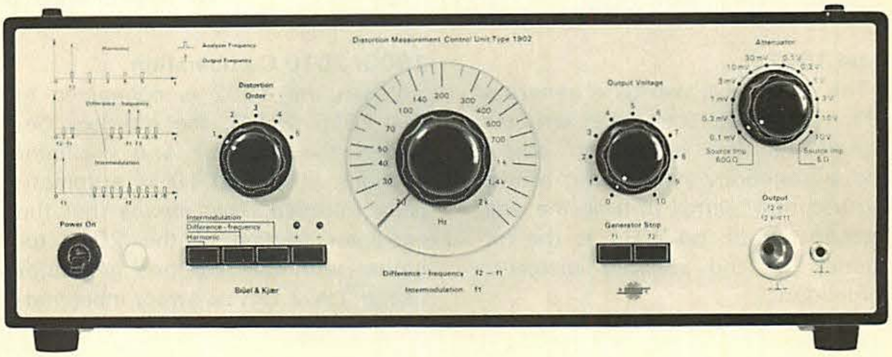
type 1902

Distortion Measurement Control Unit



FEATURES:

- Swept two-tone generator and analyzer control for harmonic, difference-frequency and intermodulation distortion measurements
- Frequency range 2 Hz to 200 kHz
- Typical distortion less than 0,01%
- Amplitude linearity better than ± 0,2 dB
- Automatic tuning of Heterodyne Analyzer Type 2010
- Automatic tracking on individual distortion components up to fifth order
- Automatic sweep with Level or X-Y Recorder
- Low frequency signal continuously adjustable from 20 Hz to 2 kHz in intermodulation mode
- Frequency difference continuously adjustable from 20 Hz to 2 kHz in difference-frequency mode
- Output voltages up to 10 V
- Output impedance of 600 Ω or 5 Ω
- Easy to operate

USES:

- Harmonic distortion measurements and analyses to DIN 45 403 and IEC 268-3
- Difference-frequency distortion measurements and analyses to DIN 45 403, IEC 268-3 and CCIF
- Intermodulation distortion measurements and analyses to DIN 45 403, IEC 268-3 and SMPTE

The 1902 Distortion Measurement Control Unit is an advanced and accurate instrument designed to automatically control the well-known Heterodyne Analyzer Type 2010 to provide swept measurement of non-linear distortion in amplifiers, loudspeakers, hearing aids, tape recorders, microphones, hydrophones etc.

The swept distortion measurements, introduced by the 1902/2010 combination, give more information and are easier to perform than the normally used method of measuring distortion at several single frequencies, a method which is very tedious and may give results that are not truly representative.

The 1902/2010 measures harmonic distortion, difference-frequency distortion and intermodulation distortion all to DIN 45 403 and IEC 268-3 standards. Difference-frequency distortion and intermodulation distortion may also be measured according to the CCIF and SMPTE methods, respectively. Further with the addition of a Time Delay Spectrometry Unit Type 5842, free field measurments in ordinary environments may be carried out using a 1902 and 2010.

The 1902 provides tuning signals for the 2010 and generates the necessary test signals for swept measurement of distortion components up to fifth order, in the frequency range 2 Hz to 20 kHz. Distortion components down to typically −80 dB can be measured. Together with the Level Recorder Type 2307 or X-Y Recorder Type 2308 automatic analysis of distortion can be performed and documented on preprinted frequency-calibrated paper.

Principle of Operation

Fig. 1 shows the principle of operation of the 1902 together with the 2010.

Type 2010

The 2010 is a frequency selective measuring amplifier and a beat frequency oscillator, both normally interlocked to operate at the same frequency. It covers the frequency range from 2 Hz to 200 kHz and has six analysis bandwidths ranging from 3,16 Hz to 1000 Hz. For further information on Type 2010 see separate product data sheet.

Type 1902

The 1902 is a two-tone generator which provides the necessary test signals for the measuring object, and a frequency synthesizer, providing a control signal to tune the analyzer section of the 2010 to the frequency of the desired distortion component.

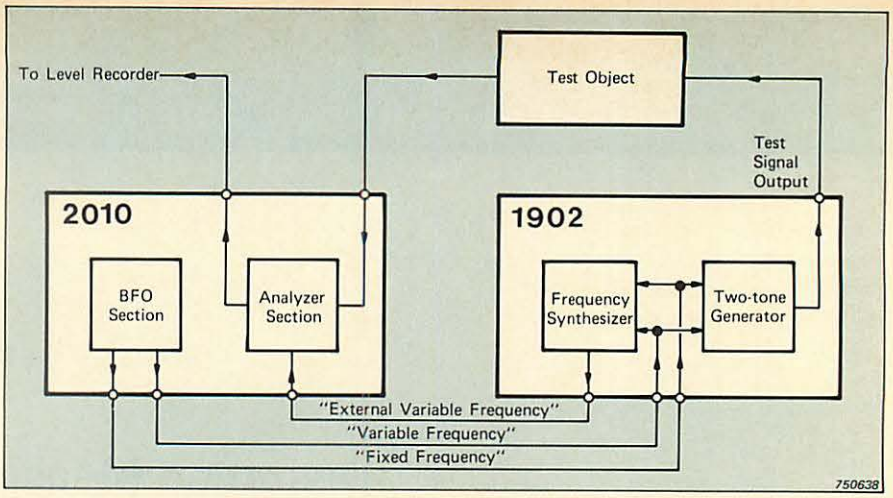


Fig. 1. Interconnection of Type 1902 and Type 2010

1902/2010 Combination

When the 1902 is connected to the 2010 (Fig. 1), the interlock between the analyzer and oscillator sections of the 2010 is automatically released. This means that the oscillator section of the 2010 together with the two-tone generator of the 1902 can be swept independently of the analyzer section of the 2010, which can now be tuned to the desired distortion component by the frequency synthesizer of the 1902. The three cables (AO 0064) required for connection of the 2010 to the 1902 are supplied with the 1902.

Description

The 1902 is equipped with three push-button controlled mode switches, "Harmonic", "Difference-frequency" and "Intermodulation", for selection of the distortion measuring mode. A five-position DISTORTION ORDER switch together with two push-button switches, "+" and "—", select the distortion component to be tracked by the 2010. A frequency calibrated dial is used for setting frequency differences between 20 Hz and 2 kHz when measuring difference-frequency distortion and for setting the lower test frequency when measuring intermodulation distortion.

As described above, the 1902 consists of a two-tone generator and a frequency synthesizer. In the following text a short description of the operation of the 1902 is given.

The clock frequency used in the 1902 is the 1,2 MHz "Fixed Frequency" from the crystal-controlled oscillator of the 2010, thereby ensuring perfect synchronization between the two instruments.

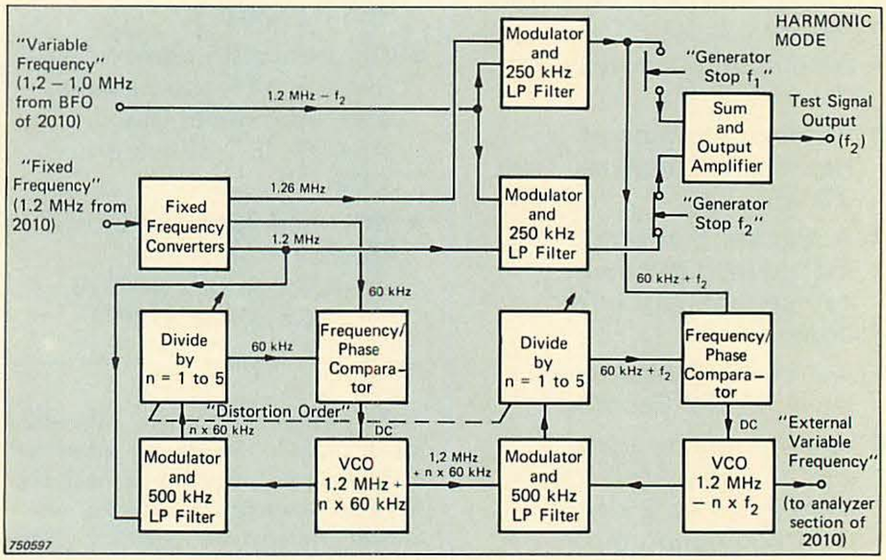


Fig. 2. Simplified block diagram of the 1902 in the "Harmonic" mode

In Figs. 2, 3 and 4, simplified block diagrams of the 1902 in the different modes of operation are shown. Fig. 5 shows the relative position of the frequencies obtained from the 1902 in the different modes of operation and the corresponding analysis frequencies.

Two-Tone Generator

The generator consists basically of a voltage controlled oscillator (VCO), two modulators, an output amplifier and an attenuator.

In the "Harmonic" mode the 1,2 MHz "Fixed Frequency" and the 1,2 to 1 MHz "Variable Frequency" from the 2010 are fed to one of the modulators, mixed and then filtered in a 250 kHz low-pass filter (see Fig.2). The resulting signal (f_2) will have the same frequency as the signal from the BFO of the 2010. This frequency is indicated on the frequency counter display of the 2010. From the modulator, the signal is fed via the GENERATOR STOP switch to the output amplifier and the OUTPUT sockets.

The signal (f_2) is used in all modes of the 1902, and in the "Difference-frequency" and "Intermodulation" modes, where two test tones are generated, it will always be the higher frequency of the two tones. See also Fig.5.

In the "Difference-frequency" mode a second tone, which follows the frequency of f_2 at a preset frequency difference below f_2, is added. The frequency difference (f_o) is set by means of the front panel frequency control potentiometer, which controls a VCO operating at 1,2 MHz $\pm f_o$ (see Fig.3). This frequency is mixed with the "Variable Frequency" from the 2010 (1,2 MHz — f_2) in a modulator and filtered in a 250 kHz low-pass filter leaving the desired frequency component $f_1 = f_2 - f_o$. See Fig.5. f_o is adjustable in the frequency range 20 Hz to 2 kHz. The two signals, f_1 and f_2, are then summed in the output amplifier to have equal amplitudes and an output voltage whose RMS value is the same as that of the single tone (f_2) in the "Harmonic" mode.

In the "Intermodulation" mode, a fixed low frequency tone (f_1) is used in addition to the sweeping tone (f_2). The frequency of this (f_1) tone can be set in the frequency range 20 Hz to 2 kHz by means of the front panel frequency control potentiometer. This tone (f_1) is obtained by mixing the 1,2 MHz $\pm f_o$ from the VCO with the 1,2 MHz "Fixed Frequency" in a modulator and filtering in a 250 kHz low-pass filter leaving f_o (= f_1). See Fig.4. f_1 and f_2 are then summed in the output amplifier, so that the amplitude of f_1 is four times the amplitude of f_2 (12 dB higher). See Fig.5.

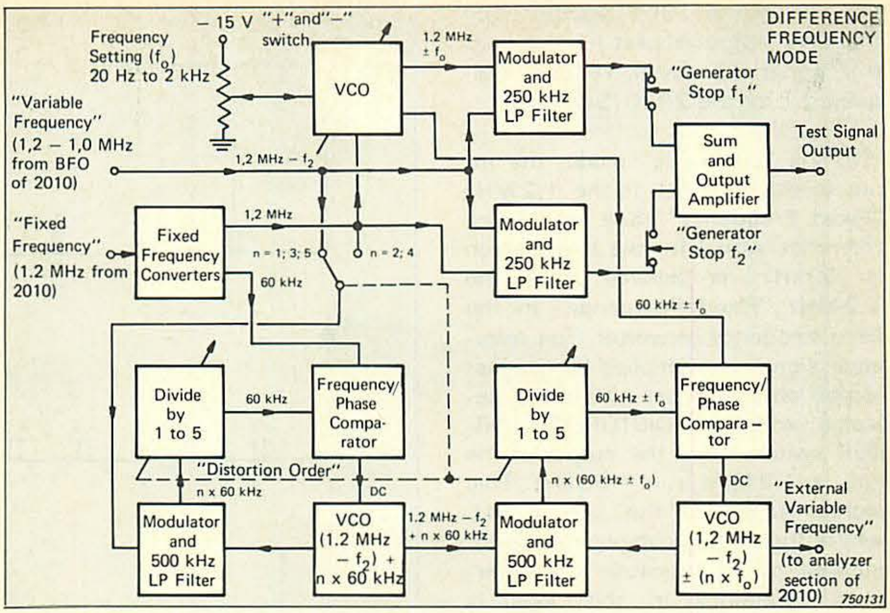


Fig.3. Simplified block diagram of the 1902 in the "Difference-frequency" mode

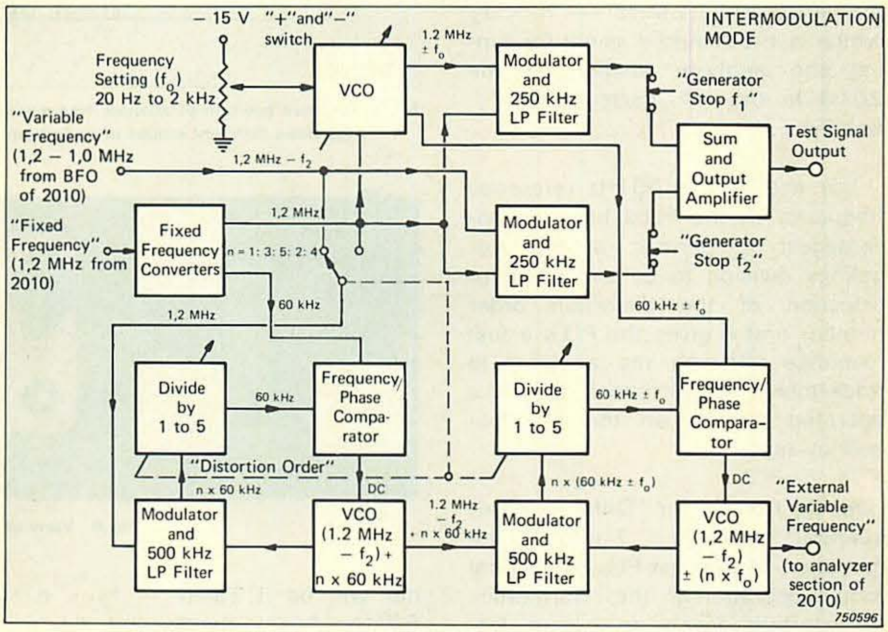


Fig.4. Simplified block diagram of the 1902 in the "Intermodulation" mode

The test signal which is available at the standard B & K coaxial OUTPUT socket of the 1902, can be varied continuously from 0 to 10 V using the OUTPUT VOLTAGE potentiometer or in 10 dB steps from 100 μV to 10 V using the ATTENUATOR. The amplitude linearity of both frequencies is better than ± 0,2 dB over the entire 2 Hz to 200 kHz frequency range. The output Impedance is either 600 Ω or 5 Ω, depending upon the setting of the ATTENUATOR. The test signal is also available at the coaxial BNC OUTPUT socket on the rear of the instrument (Fig.6). An ADJUST potentiometer on the rear panel is provided for adjusting the amplitude of f_2. The adjustment range is ± 1 dB.

Two push-button switches, GENERATOR STOP, are provided to switch off one or both of the test frequencies when setting up and adjusting the test object.

Frequency Synthesizer

The synthesizer which generates the control signal necessary to tune the analyzer section of the 2010 to any desired distortion component up to the fifth order in the frequency range 2 Hz to 200 kHz, consists of two phase-locked loops (PLL). The input frequencies to the synthesizer are the "Fixed Frequency" (1,2 MHz) and the "Variable Frequency" (1,2 to 1,0 MHz) from the 2010. The BNC input sockets for these signals are situated on the rear of the 1902 together with the BNC output socket for the control signal, "External Variable Frequency", for the 2010. See Fig.6.

In the "Harmonic" mode, the input to the first PLL is the 1,2 MHz "Fixed Frequency". See Fig.2. The reference signal for the loop, which is 60 kHz, is derived from the 1,2 MHz "Fixed Frequency" in the fixed frequency converter. The reference signal is multiplied by the distortion order number n which is selected with the DISTORTION ORDER switch. Thus the output of the PLL is 1,2 MHz + n × 60 kHz. This signal is fed to the second PLL where the 60 kHz component is substituted by f_2, because the reference frequency in this loop is 60 kHz + f_2. This gives an output frequency of 1,2 MHz — n × f_2 which is the required signal for tuning the analyzer section of the 2010 to the n^{th} harmonic of f_2. See Fig.5.

The use of the 60 kHz reference frequency in the PLLs has two advantages: It permits simple frequency division to be employed for selection of the distortion order number and it gives the PLLs a fast response allowing the analyzer to track more rapidly than if the PLLs operated directly on the low frequency signal.

In the even order "Difference-frequency" modes (n = 2 and 4), the operation of the first PLL is identical to the operation in the "Harmonic" mode, thus giving an output frequency 1,2 MHz + n × 60 kHz. However, the second PLL now uses a reference signal, which is 60 kHz + f_o, where f_o is the frequency difference set with the frequency control potentiometer. The PLL therefore substitutes the 60 kHz component with f_o, giving an output frequency of 1,2 MHz — n × f_o. Thus with n = 1, the 2010 will be tuned to the "2—" distortion order component ($f_2 - f_1 = f_o$) and with n = 2, to the "4—" component, that is the frequency difference and its second harmonic, respectively. See Figs.3 and 5.

In the odd order "Difference-frequency" modes (n = 1, 3 and 5) the input to the first PLL is 1,2 MHz — f_o, which means that the output sig-

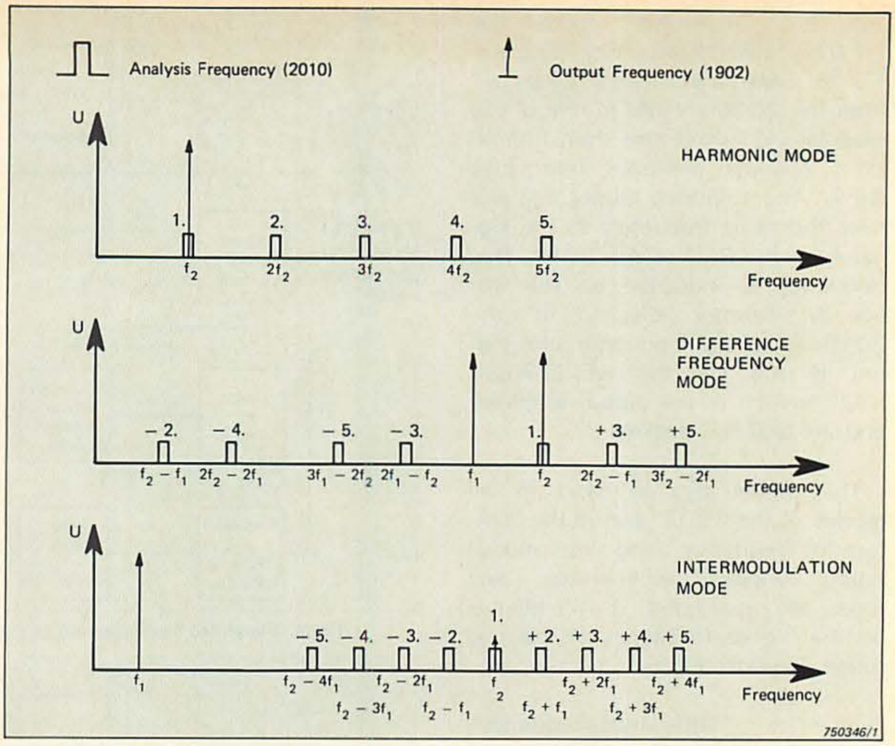


Fig.5. Relative position of analysis frequencies of 2010, and test signal frequencies of 1902 in the three different modes of operation

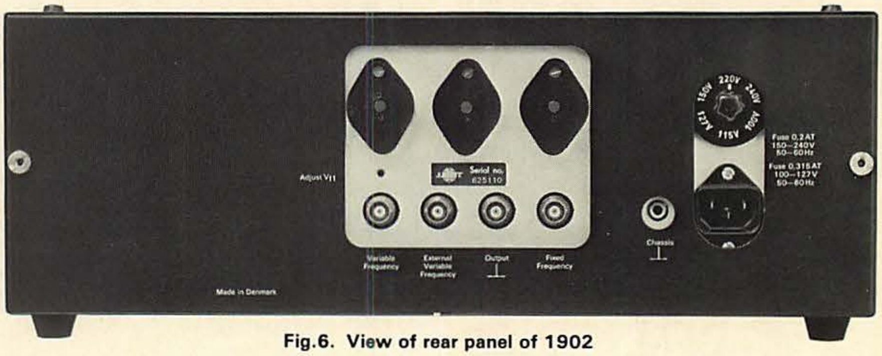


Fig.6. View of rear panel of 1902

nal will be 1,2 MHz — f_2 + n × 60 kHz. Again, the second PLL replaces the 60 kHz component with f_o. Now, depending on whether the reference signal is 60 kHz + f_o or 60 kHz — f_o, the "+" or "—" distortion order component will be selected. The resulting analyzer control signal will therefore be 1,2 MHz — f_2 ± n × f_o. The reference signal is chosen with the "+" and "—" push-button switches. It should be noted that in this mode the frequency dividers in the PLLs do not divide by the actual distortion order number. For example, the "3+" component lies 1 × f_o above f_2, hence n must be one. Likewise for the "5+" and the "3—" components, n must be 2; and for the "5—" component the dividers must divide by 3. See also Fig.5.

The operation of the frequency synthesizer in the "Intermodulation" mode (Fig.4) is virtually identical to the operation in the odd order "Difference-frequency" mode, the only difference being that in the "Intermodulation" mode, the frequency dividers divide by the actual distortion order number n — 1.

Distortion

The distortion of the 1902/2010 combination itself is very low. In the range from 100 Hz to 100 kHz the distortion is less than 0,02% and less than 0,03% in the range 15 Hz to 200 kHz, measured on any distortion component in any mode. Second order and third order distortion is typically less than 0,01% and fourth and fifth order less than 0,004%. However, in the "Intermodulation" mode these figures may be

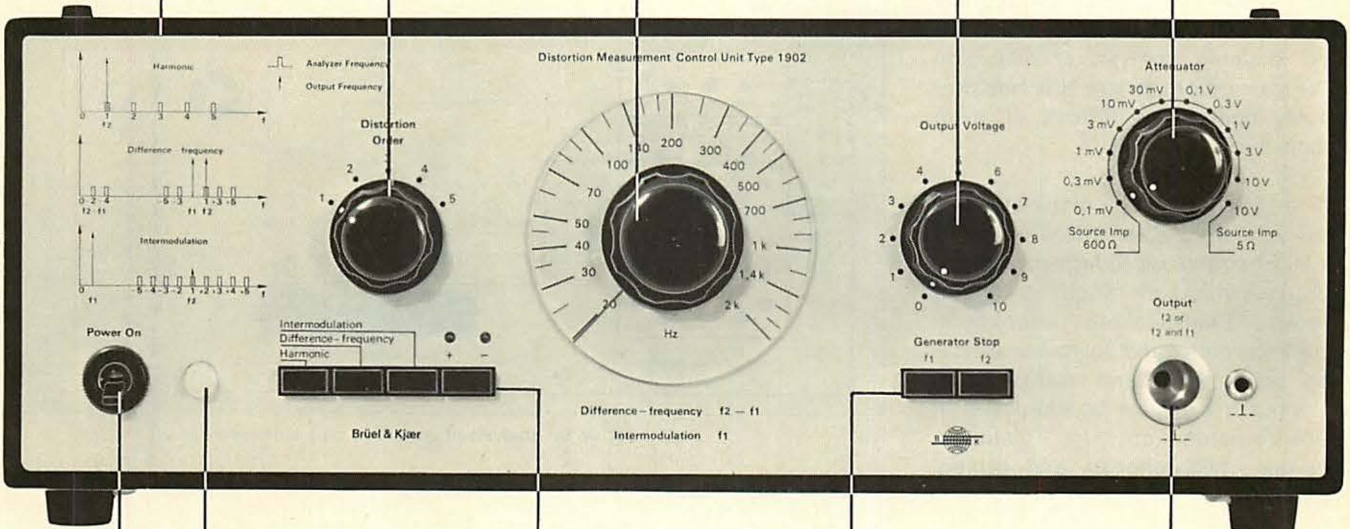
Diagram indicating the relative position of the analysis frequencies of the 2010 and the test signal frequencies of the 1902 in the different modes of operation

Frequency calibrated dial for setting the frequency difference between the test frequencies in the "Difference — frequency" mode or setting the lower test frequency in the "Intermodulation" mode

ATTENUATOR variable in 10 dB steps for selection of output voltages between 0,1 mV and 10 V. The output voltage is continuously variable with the OUTPUT VOLTAGE potentiometer within each step. The source impedance is 600 Ω. In the 10 V/5 Ω-position the output voltage can be varied between 0 and 10 V and the source impedance is 5 Ω

5-position rotary-switch for selection of the order of the distortion component to be measured

OUTPUT VOLTAGE potentiometer for continuous variation of the voltage, either within each step of the ATTENUATOR (600 Ω positions) or from 0 to 10 V (5 Ω position)



GENERATOR STOP switches for switching off one or both test frequencies when setting up or adjusting the test object

POWER ON indicator lamp

POWER ON switch

Push-button operated mode switches for selection of the distortion measuring mode

Standard B & K coaxial output socket

improved by a factor of about three by inserting a high-pass filter between the output of the test object and the input of the analyzer as shown in Fig.7, to filter out the test frequency f_1.

The 1902/2010 combination is self-checking, hence the output from the 1902 can be connected directly to the input of the 2010 in order to measure the distortion residual of the system in any mode.

General

The 1902 is fully compatible with all Heterodyne Analyzers Type 2010 currently being delivered. However, for some earlier models of the 2010, modifications may be necessary. For 2010s with serial numbers up to 401819, an additional B & K socket (EXTERNAL VARIABLE FREQUENCY 1,2 to 1,0 MHz) must be added to the rear panel to permit external control of the analyzer section. In addition, all instruments up to serial number 476289 require a modification of the COUNTING TIME switch in order to be able to read the frequency to which the analyzer is tuned.

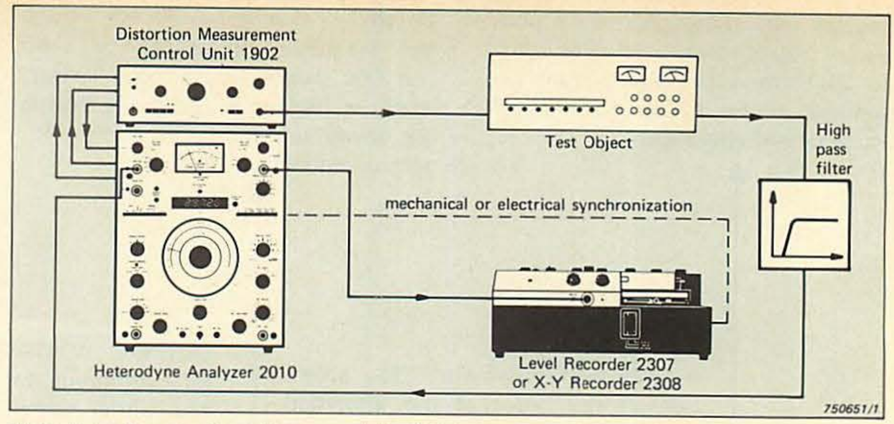


Fig.7. Extending the dynamic range of the 1902/2010 combination in the "Intermodulation" mode by means of a simple, high pass filter

Examples of Use

The great flexibility and versatility of the 1902/2010 combination allows detailed analysis of distortion to be carried out where this has previously been very difficult or even impossible.

The 1902/2010 combination is mainly intended for measurements on Hi-Fi-sound reproduction and recording equipment such as microphones, loudspeakers, amplifiers, tape recorders, and telecommunication equipment, and transmission lines but it can also be employed in measurements on, for instance, pick-ups, hydrophones and projectors.

In the following section, a few examples of typical measuring setups, showing the possibilities of the system are given.

Fig.8 shows a set-up which can be utilized for measurmement and analysis of harmonic, difference frequency or intermodulation distortion analyses on various types of equipment. By adding a Level Recorder Type 2307 or X-Y Recorder Type 2308, the 2010 can be swept automatically and the measurement or analysis can be graphically presented on frequency calibrated paper.

Fig.9 shows an analysis of the 3rd order (—) difference-frequency distortion of a Hi-Fi tape recorder recorded by means of the set-up shown in Fig.8.

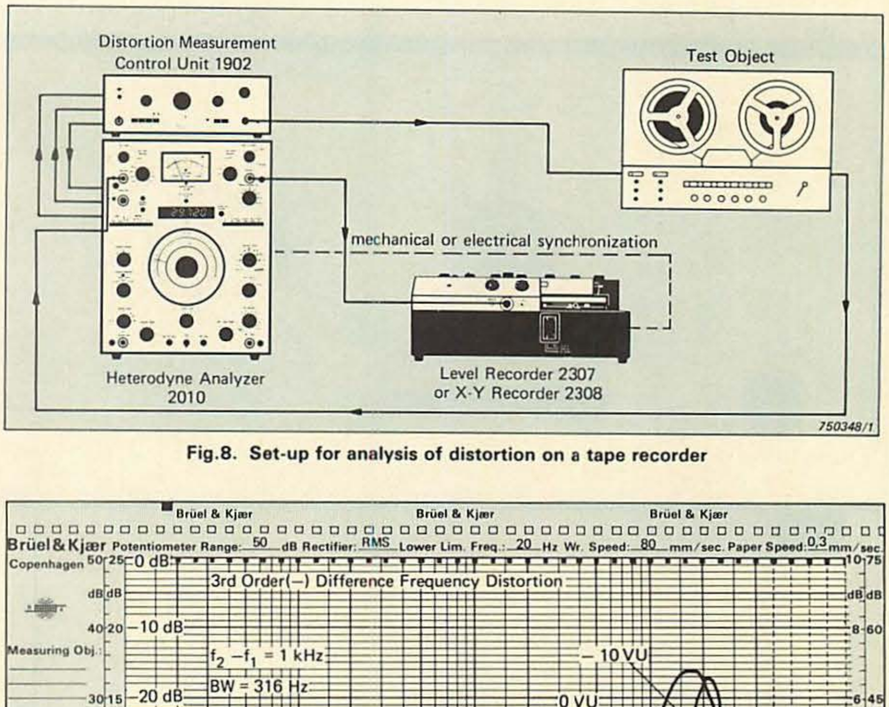


Fig.8. Set-up for analysis of distortion on a tape recorder

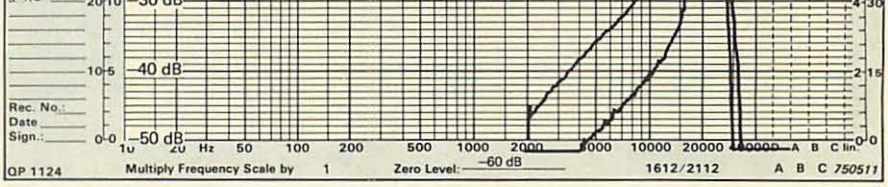


Fig.9. Difference-frequency analysis recorded with the set-up in Fig.8

In the set-up in Fig.10, the 1902/2010 are employed in measuring and recording the distortion characteristics of a loudspeaker. Efficient loudspeakers can be driven directly by the 1902, while less efficient loudspeakers require a power amplifier. Due to small dimensions and wide frequency range, a 1/2" Condenser Microphone, such as Type 4133, is preferred on the receiving side of the set-up.

The 1902 may also be employed in microphone measurements. Fig.11 shows a set-up which will be very suitable for measurement of the intermodulation and difference-frequency distortion characteristics of microphones. Two loudspeakers are used, one for each test frequency, in order to eliminate the difference frequency and intermodulation distortion of the loudspeaker itself. The test frequency f_2 is obtained directly from the 2010, while the f_1 signal is supplied from the output of the 1902, with the f_2 signal switched off by means of the GENERATOR STOP switch.

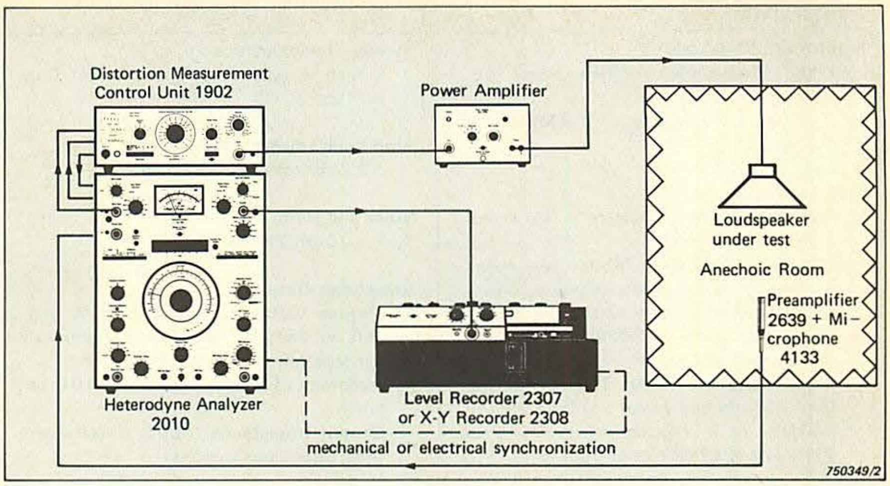


Fig.10. Set-up for recording the distortion characteristics of a loudspeaker

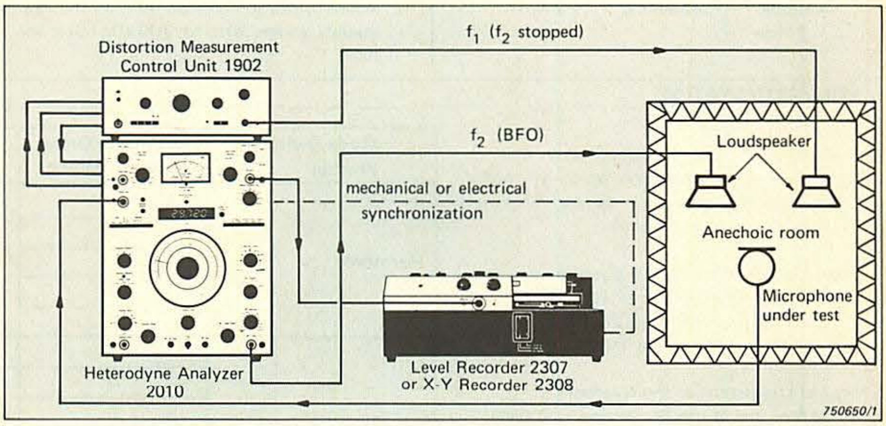


Fig.11. Set-up for recording intermodulation and difference-frequency distortion analyses of a microphone

For free field measurements on loudspeakers and other electro-acoustic equipment in ordinary, non-anechoic environments the instrument setup shown in Fig.12 can be employed. This makes use of the Time Delay Spectrometry Unit Type 5842 for control of the 1902/2010 and together with a Phase Meter Type 2971 enables fast, time selective magnitude and phase response measurements to be made. Moreover, with the addition of a Type 2033 Narrow Band Spectrum analyzer, the magnitude versus time response may be obtained.

An important virtue of the Time Delay Spectrometry as performed by Type 5842 is its capability of rejecting noise and reflections. In addition it takes only a few seconds to complete a measurement plus provide an almost simultaneous graphical representation of the measured free field response on an oscilloscope. Alternatively where hard copy, plot is required, an X-Y Recorder such as Type 2308 can be included in the measurement setup.

For further details on this and other applications of the Time Delay Spectrometry Unit, please ask for the separate Product Data for Type 5842.

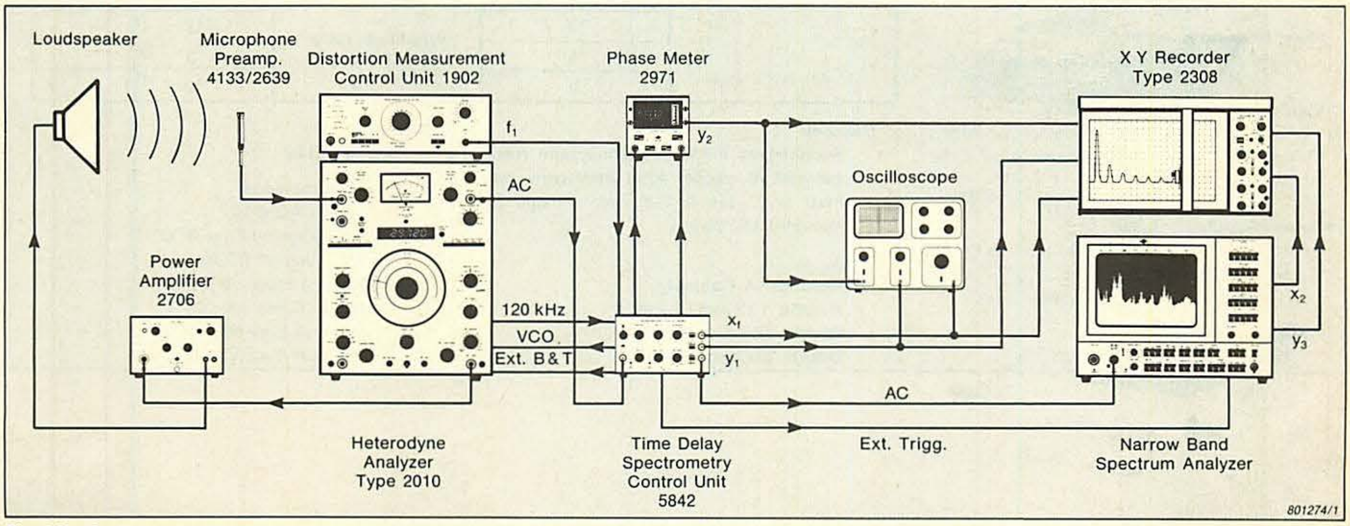


Fig. 12. Setup including the Time Delay Spectrometry Control Unit Type 5842 for free field loudspeaker measurements in ordinary environments

Specifications 1902

GENERATOR

Input from 2010 (BNC):
- **Fixed Frequency:** 1,2 MHz (clock frequency)
- **Variable Frequency:** 1,2 MHz to 1,0 MHz

Test Signals:
- **Harmonic Mode:** Single tone (f_2) swept from 2 Hz to 200 kHz
- **Difference-frequency Mode:** Two tones (f_1 and f_2) with a fixed frequency difference adjustable from 20 Hz to 2 kHz, swept from 2 Hz to 200 kHz. The tones are of equal amplitude
- **Intermodulation Mode:** Two tones, one fixed (f_1) and one swept (f_2) from 2 Hz to 200 kHz. f_1 is adjustable from 20 Hz to 2 kHz and is 12 dB higher than f_2

Sweep Characteristics:
Linear or logarithmic (see Product Data for Type 2010)

Amplitude Linearity of f_1 and f_2:
± 0,2 dB from 2 Hz to 200 kHz

Noise and Hum:
< —70 dB (2 Hz to 200 kHz)

Attenuator Output:
- **Output Voltage:** 100 μV to 10 V, variable in steps of 10 dB and continuously variable within each step
- **Accuracy of Steps:** ± 0,1 dB re 10 V position
- **Output Impedance:** 600 Ω (unbalanced) in all attenuator positions

Direct Output:
- **Output Voltage:** 0 to 10 V continuously variable
- **Maximum Output Current:** 40 mA peak (short circuit protected)
- **Maximum Output Power:** 500 mW into 200 Ω
- **Output Impedance:** 5 Ω (unbalanced)
- **DC Offset:** < ± 50 mV

Frequency Dial:
- **Intermodulation Mode:** Sets f_1 from 20 Hz to 2 kHz
- **Difference-frequency Mode:** Sets $f_2 - f_1$ from 20 Hz to 2 kHz
- **Accuracy:** ± 4%

FREQUENCY SYNTHESIZER

Input from 2010 (BNC):
- **Fixed Frequency:** 1,2 MHz (clock frequency)
- **Variable Frequency:** 1,2 MHz to 1,0 MHz

Output to 2010
- **External Variable Frequency:** 1,2 MHz to 1,0 MHz to tune the 2010 to the selected distortion component in the frequency range 2 Hz to 200 kHz. See the table

1902/2010 SYSTEM

Measuring Modes:
Harmonic, difference-frequency and intermodulation distortion up to 5th order. All distortion components are measured individually. See the table

Mode Switch Position		Distortion Order Switch Position	Test Frequencies (1902)	Analysis Frequency (2010)
Harmonic		1	f_2	f_2
		2		$2 \times f_2$
		3		$3 \times f_2$
		4		$4 \times f_2$
		5		$5 \times f_2$
Difference frequency		1	f_2	f_2
	+	3	f_2 and f_1	$2f_2 - f_1$
		5		$3f_2 - 2f_1$
	—	2		$f_2 - f_1$
		3		$2f_1 - f_2$
		4	Amplitude ratio: $f_1{:}f_2 = 1{:}1$	$2f_2 - 2f_1$
		5		$3f_1 - 2f_2$
Intermodulation		1	f_2	f_2
	+	2	f_2 and f_1	$f_2 + f_1$
		3		$f_2 + 2f_1$
		4		$f_2 + 3f_1$
		5		$f_2 + 4f_1$
	—	2		$f_2 - f_1$
		3	Amplitude ratio: $f_2{:}f_1 = 1{:}4$	$f_2 - 2f_1$
		4		$f_2 - 3f_1$
		5		$f_2 - 4f_1$

Distortion of 1902/2010 System:
< 0,02% from 100 Hz to 100 kHz
< 0,03% from 15 Hz to 200 kHz
(any component in any mode)

Typical Distortion of the System:
- **2nd or 3rd Order Distortion:** < 0,01%
- **4th or 5th Order Distortion:** < 0,004%

Maximum Sweep Rate:
5 s/decade while maintaining phase-lock (maximum paper speed of 10 mm/s on Level Recorder Type 2307)

Analyzer Inputs and Filter characteristics:
See Product Data for Type 2010

Temperature Range:
10° to 40°C (50° to 140°F)

Max. Humidity:
90% RH (non condensing) at 30°C

Electromagnetic Compatibility:
Complies with Class B device of American FCC (Federal Communication Commission) Rules

Power Supply:
100, 115,127, 220, 240 V (50 to 60 Hz) AC ± 10%
Complies with IEC 348 safety class I

Power Consumption:
Approximately 25 VA

Cabinet:
Supplied as model A (light-weight metal cabinet), B (model A in mahogany cabinet) or C (as A but with flanges for standard 19" racks)

Dimensions (A-Cabinet):
- **Height:** 133 mm (5,2 in)
- **Width:** 380 mm (15 in)
- **Depth:** 200 mm (7,9 in)

Weight:
5,8 kg (13 lb)

Accessories Included:
- 3 Cables AO 0127
- 1 B & K Coaxial Plug JP 0101
- 1 BNC Plug JP 0035
- 2 Banana Plugs JB 0002
- 1 Power Cable AN 0010
- 1 315 mA Fuse VF 0042
- 1 200 mA Fuse VF 0012