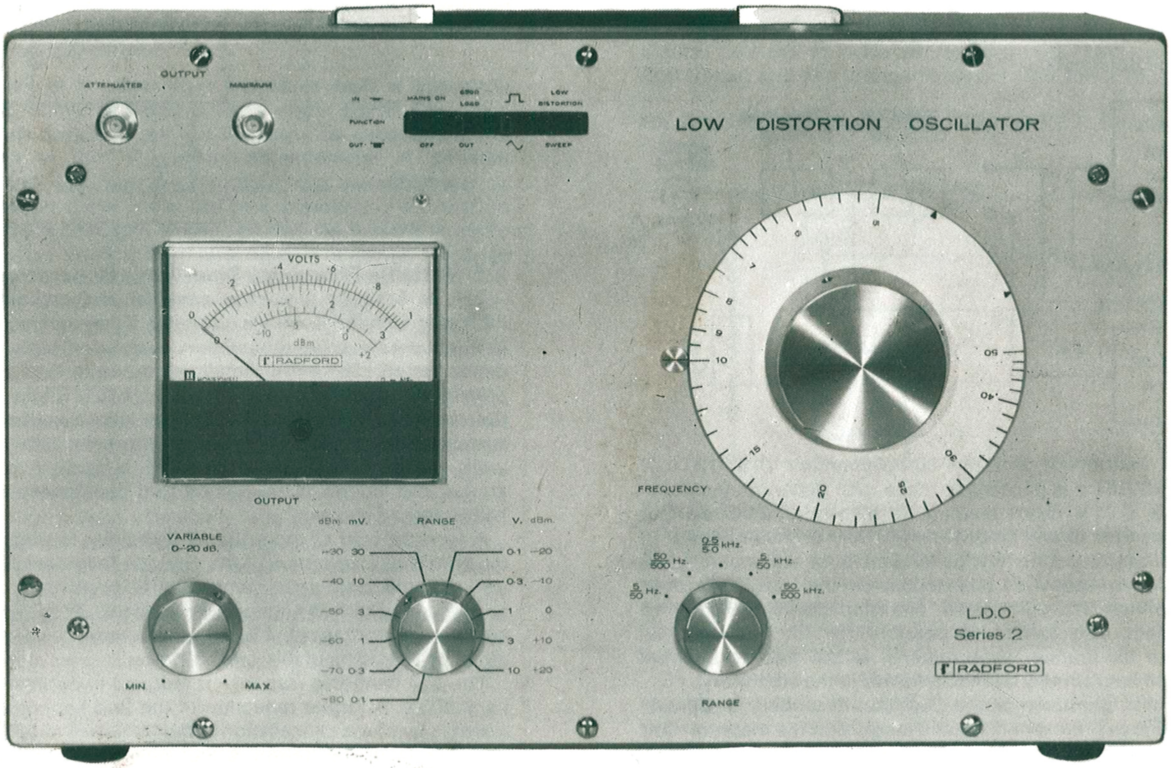
RADFORD



LOW DISTORTION OSCILLATOR

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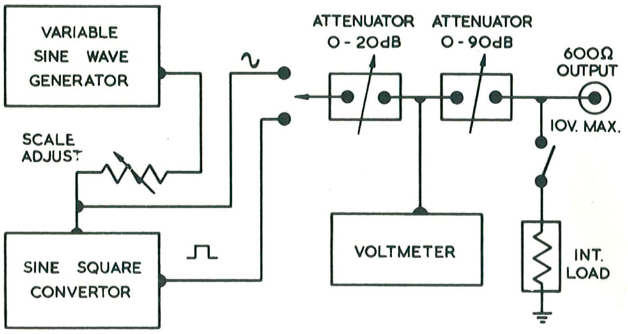
1. INTRODUCTION

This leaflet describes the Low Distortion Oscillator; Series 2. A complementary instrument, the DISTORTION MEASURING SET; Series 2 is described in Leaflet A.71.

The Low Distortion Oscillator was designed originally for use in the development of high quality audio equipment. However, its comprehensive facilities and low price makes the instrument attractive to audio, sound and line engineers for routine measurements and maintenance. The main feature of the instrument is its low distortion but it also has attraction in its high inherent frequency stability and flexibility.

Commercial oscillators, generally, have a distortion content from 0.25% to 1.0% and higher grade laboratory instruments from 0.1% to 0.25%. In order to obtain a low distortion signal it has been necessary to filter the Oscillator to reduce the harmonic content. Filters are rarely tuneable, and consequently distortion measurements have to be taken at the frequencies of the filters available.

Fig. 1. Block Schematic.



With this instrument and the complementary DISTORTION MEASURING SET it is possible to make total distortion measurements below 0.01% direct reading, in a few minutes, without ancillary apparatus of any kind. Time is a very important factor in the modern laboratory. In the development of advanced audio equipment it is essential that measurements can be taken accurately, simply and with speed. The simplicity of operation of the instrument also makes it possible for the maintenance technician to do routine measurements in the field to a higher standard than has formerly been practicable in the laboratory.

The distortion produced by the Oscillator described, is approximately 0.005% over most of the audio range, and the measurement capability of the DISTORTION MEASURING SET is of the same order.

Aspects of design, construction and operation are described below.

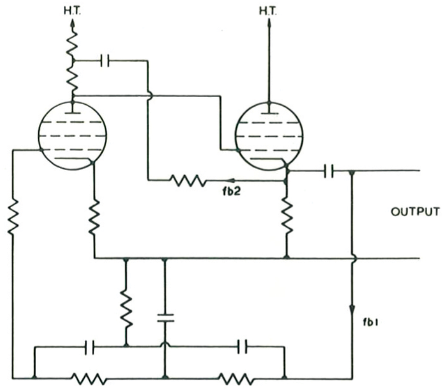
2. DESIGN

The instrument comprises the following functions.

1. Variable Frequency Sine-Wave Generation.
2. Sine/Square Conversion.
3. Output Monitoring and Measurement.
4. Attenuation.

A schematic diagram of the arrangement is shown in Fig. 1, and the functions are briefly described below.

Fig. 2. Oscillator.
Simplified Circuit.



2:1 Variable Frequency Sine-Wave Generation

This is basically a voltage amplifier and cathode follower of high gain with feedback via a parallel 'T' network permitting single frequency sine-wave generation with very high off-frequency degeneration. The basic circuit is shown in Fig. 2. Feedback is applied through the parallel 'T' network fb1. Slight off balance of the network produces the necessary phase shift to initiate and sustain the oscillation. Due to the high selectivity of the 'T' network considerable negative feedback is applied to the amplifier at the 2nd harmonic frequency and full feedback at the 3rd harmonic and above.

A forward gain of more than 1,000 times is obtained by using the high input resistance of the cathode follower V2 as the anode load for the high gain pentode V1. High gain ensures high negative feedback at harmonic frequencies. Assuming an inherent amplifier distortion of 1% the high order harmonic response could be 1/1000th of this, i.e. 0.001%.

The 2nd harmonic response is reduced to approximately 1/333 i.e. 0.003%. A further reduction of the 2nd harmonic distortion is possible by phase cancellation in the bootstrap circuit fb2.

A feature of the design is that phase shift in the amplifier is virtually neutralized by a minute change in oscillator frequency, leaving the frequency stability dependant upon the components used in the parallel 'T' network.

Fig. 3a. Distortion curve—Thermistor control.

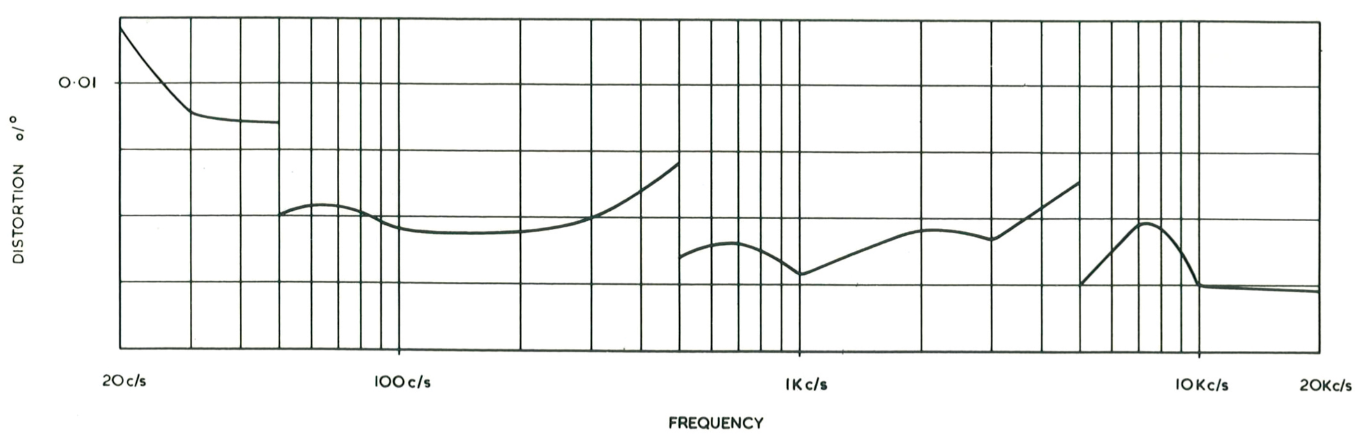
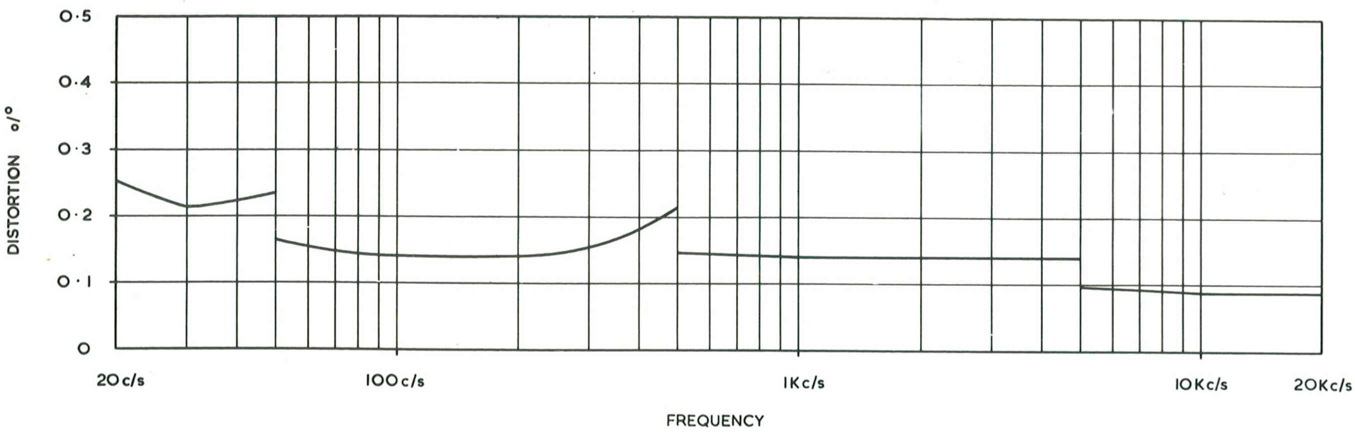


Fig. 3b. Distortion curve—F.E.T. Control.



Due to the low output resistance of the high mutual conductance cathode follower, it is practicable to feed a conventional 600 Ohm attenuator through a low value buffer resistance without increasing the distortion seriously, yet providing an output of 10V. r.m.s. across 600 Ohms.

The distortion of the sine-wave generator itself is inherently very low, and of the order of 0.001% under 5,000 Ohm load conditions. This distortion may be increased by variations in the out-of-balance of the 'T' ganged potentiometer at different frequencies, and will vary slightly from one potentiometer to another. Distortion is also increased by a reduction of the load on the cathode follower output stage, and may be 0.005% at audio frequencies, when the 600 Ohm attenuator is in circuit. Range to range distortion is shown for a typical instrument in Fig. 3.

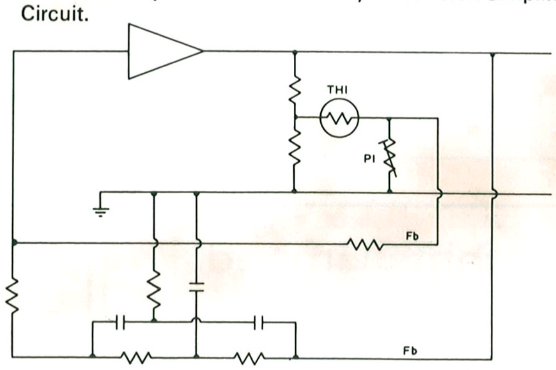
If it is desired to use the instrument in a condition for the lowest distortion output, it can be operated at the +20 dBm attenuator output position into a high resistance load using the 5kOhm 0–20 dB potentiometer for total attenuation adjustment. The 600 Ohm attenuator is not in circuit when switched to +20 dBm.

Two methods of amplitude stabilisation are used which may be selected by a switch on the front panel engraved 'Low Distortion' and 'Sweep'. Thermistor control is used in the low distortion condition and a simplified circuit is shown in Fig. 4. To obtain a very low distortion output a relatively long time—constant thermistor is used. If the frequency is changed by operation of the Frequency Control or Frequency Range Switch the thermistor takes a time inversely proportional to frequency to reach amplitude stability. To enable the instrument to be used for sweep response measurements an alternative method of stabilisation using a field effect transistor is incorporated as shown in the simplified circuit Fig. 5.

2:2 Sine/Square Conversion

This is a Schmitt trigger arrangement which may be used over the complete frequency range of the instrument. The rise time is approximately 0.2 μsecs but the fall time may be higher than this at high frequencies depending upon the capacitance loading of the output termination. Fig. 6 shows a reproduction of photographs of typical square-wave performance at various frequencies when loaded with 600 Ohms resistance.

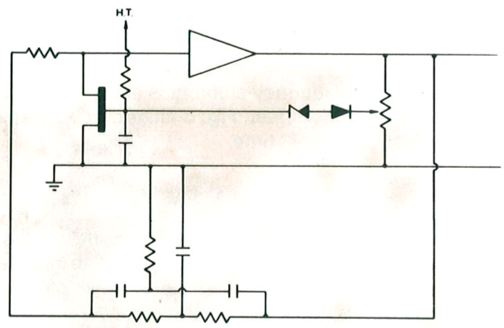
Fig. 4. Oscillator Amplitude Stablisation by Thermistor. Simplified Circuit.



2:3 Output Monitoring

The instrument is provided with a valve voltmeter for output monitoring. A schematic arrangement of the voltmeter and its connection in the circuit is shown in Fig. 7. The meter has three scales: +2 dB to —12 dB (0 dBm =0.775V. =1 mW. into 600 Ohms) and two voltage ranges of 10.0 and 3.16 approx. f.s.d.

Fig. 5. Oscillator Amplitude Stability by F.E.T. Simplified Circuit.



2:4 Output Attenuation

The output attenuator has a range 110 dB, with two controls. The first is a wirewound potentiometer with a range of 20 dB, the slider of which feeds a combination of 'T' networks switched to permit attenuation in 10 dB steps when terminated with 600 Ohms. This combination provides continuously variable attenuation from +20 dBm to —90 dBm, meter monitored.

As the voltmeter is used to monitor the output of the 20 dB variable attenuator, the output voltage across 600 Ohms is known within the accuracy of the attenuator and meter, i.e. 2% approximately. The switch attenuation marking is with reference to 0 dBm. This arrangement conforms with present day practice, and the output is known directly in respect of voltage and dB above and below zero dBm reference. It is essential that the attenuator be loaded with the incorporated 600 Ohm resistance or an external non-reactive load for correct voltage output of the attenuator.

Fig. 7. Valve Voltmeter. Simplified Circuit.

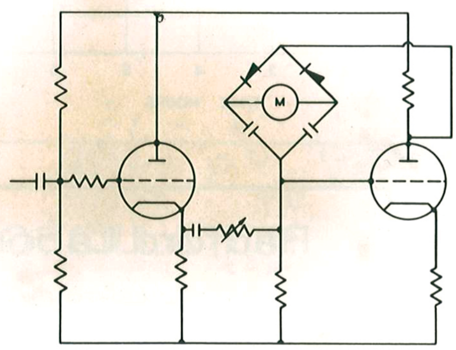
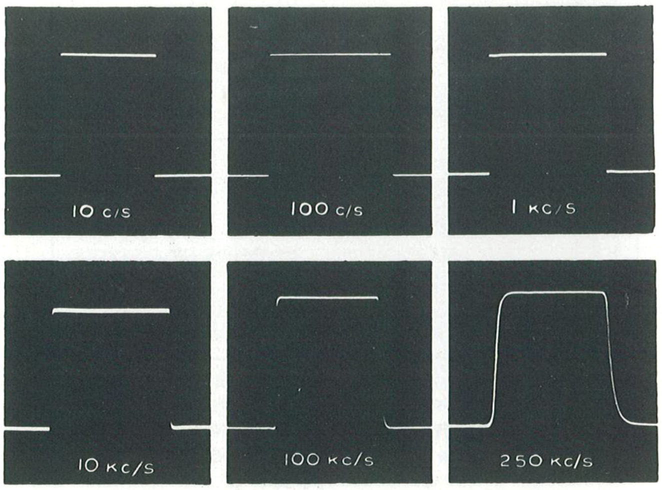


Fig. 6. Reproduction of Square Waves.



3. FREQUENCY STABILITY

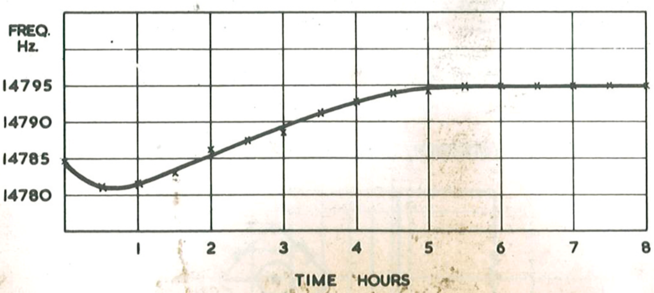
The bandwidth at the null point of the DISTORTION MEASURING SET when balanced for measurement at 0.03% f.s.d. and below is extremely narrow and good oscillator stability is therefore essential.

The stability of the Low Distortion Oscillator exceeds the requirements in this respect. After the instrument has become thermally stable the frequency stability is exceptional although no claims are made in this respect. Fig. 8 illustrates a measurement of frequency deviation against time.

The case of the instrument is constructed from mild steel and the panel is of 10 gauge hard aluminium. The case is finished grey/green wrinkle and the panel light grey gloss, stove enamelled. The panel is silk screen printed with black characters. The knobs and dials are of aluminium secured by hard socket screws. Chassis work is of steel, zinc plated. All components are of the highest quality obtainable. Printed wiring boards are manufactured in our own factory.

All RADFORD equipment is designed for satisfactory operation continuously in ambient temperatures and humidities experienced indoors in tropical climates, providing adequate ventilation is arranged.

Fig. 8. Frequency Stability Characteristic —Thermistor control.



Frequency Range:		5 Hz —500 kHz (5 ranges)
Output Impedances:	1.	5 kOhms potentiometer, slider output.
	2.	600 Ohm 'T' attenuator. Internal or external load, switched.
Output Voltage:		10V. r.m.s.
Output Attenuation:	1.	5 kOhm potentiometer. Basically for interpolation with 600 Ohm 'T' network. Variable attenuation of +2 dBm to —12 dBm read from monitoring meter.
	2.	600 Ohm 'T' networks switched for levels +20 dBm in 10 dB steps to —80 dBm when terminated. Accuracy 1%.
Sine Wave Distortion:		0.005% max. mid-band frequencies (see graph) 600 Ohm terminated.
		5 kOhm attenuator unterminated 0.003% max. mid-band frequencies.
Hum Content of Output:		Better than —100 dB below output.
Square Wave Conversion:		
Mark Space Ratio:		1:1
Rise Time:		200 n. secs.
Overshoot and Ringing:		Negligible
Frequency Stability:		See graph
Meter:		
Type:		100 μA, f.s.d. 3½"
Scales	1:	0–10
	2:	0–3.16 (V10)
	3:	dBm, +2 dB to —12 dB. (0 dBm =0.775V.)
Calibration Accuracy:		1% f.s.d.
Mains Input:		100–140V. 200–250V. 50/60 Hz
Size: Overall		10½" x 17" x 8½" (26 x 45 x 21 cms)
Weight:		(11 kilos)
Finish:		
Case:		Steel, stove enamelled grey/green wrinkle.
Panel:		Aluminium 10 s.w.g. stove enamelled light grey. Characters silk screen printed black.
Knobs:		Lathe turned aluminium. Fixed by hardened steel socket screws.
Frequency Dial:		16 s.w.g. natural anodised aluminium. Silk screen printed black characters.

Radford Laboratory Instruments Limited.

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