SECTION 16

PORTABLE INTERMODULATION TESTER PIT/1

Introduction

The PIT/1 is a small portable instrument designed to assist rapid routine checking for non-linearity in amplifiers and related equipment.

Previous BBC practice is assessing distortion due to non-linearity has been to apply pure tone to the input of the equipment and to measure the total harmonic distortion at the output. As the ear is not sensitive to harmonics unless they are fairly strong or include high-order terms (such as the seventh), it cannot be used as the detector and objective measurements with filters and a meter are essential. Moreover, the degree of objectionableness of harmonics increases with their order[1], and the normal technique of measuring total distortion does not take account of the relative magnitudes of the individual terms; hence an objective measurement and the subjective effect may not correlate well.

When, however, tones of more than one frequency are applied simultaneously to a system, any non-linearity causes intermodulation[2], and as the resulting sum and difference tones need not be harmonically related to the original frequencies, the subjective effect can be considerable. It thus becomes possible to use the ear as the detector of distortion and to dispense with filters. This simplifies the apparatus considerably, and makes it possible to built a small portable intermodulation tester which can be placed adjacent to the equipment that is to be checked.

The PIT/1 is not intended for making accurate measurements of distortion, but is designed for checking that distortion is not audible at 4 db above the peak levels which programme will reach. This 4 db has been found to provide a good margin of safety against errors of line-up and differences in judgment on the part of different operators (in practice surprisingly small), so that an equipment under test need not be rejected from service unless distortion is clearly audible. Since programme normally contains large numbers of simultaneously existing tones, the results of intermodulation tests should correlate well with those of ordinary listening checks on programme quality.

1. Shorter, D. E. L. 'The Influence of High-Order Products in Non-Linear Distortion.' *Electronic Engineering*, Vol. 22, No. 226 (April, 1950), pp. 152-153.

2. *Engineering Training Supplement*, No. 3, issue 2, page 18.

General Description

The front panel of the PIT/1 carrying the controls is shown in Fig. 16.1, and a schematic diagram illustrating the method of operation is given in Fig. 16.2. A 1-kc/s oscillator is embodied in the instrument, and the output of this, mixed with mains-derived 50-c/s tone at an 8-db lower level, is fed via coarse and fine attenuators and a 12-db loss-pad to the amplifier under test, the output of which has been adjusted to standard line-up level using a T.P.M. The amplified signal is returned to the tester, and thence to a listening circuit. By the operation of a key, the 12-db pad can be removed from the feed to the amplifier input, and a corresponding loss-pad inserted into the listening circuit, the level in which thus remains constant, while any non-linearity in the amplifier introduces intermodulation products which are readily detectable. Since the amplifier output is initially adjusted to the normal line-up level, the 12-db increase corresponds to an output 4 db above normal programme peaks.

The instrument is built into a sheet-metal case with a carrying handle at the top and ventilating louvres at the sides. The overall dimensions are 11 in. by 8½ in. by 7½ in. approximately. A permanently-attached mains cable emerges through a rubber grommet at a corner of the front panel, and can be coiled up for transport round cleats fitted on one side.

Circuit Description (Fig. 24)

A complete circuit diagram of the PIT/1 is given in Fig. 24.

The 1-kc/s tone is generated by V1, which is connected as a cathode-coupled oscillator tuned by C1 and L1; a thermistor, TH 1, which stabilises the operating level, is connected across a cathode-circuit resistor, R4. The signal output is taken from the grid end of L1 via C3 and R7 and applied to the *Mixed Tone Fine* control R11, in parallel with a mains-derived *50*-c/s tone applied via R8 and the pre-set *50-c/s Adjust* control R9.

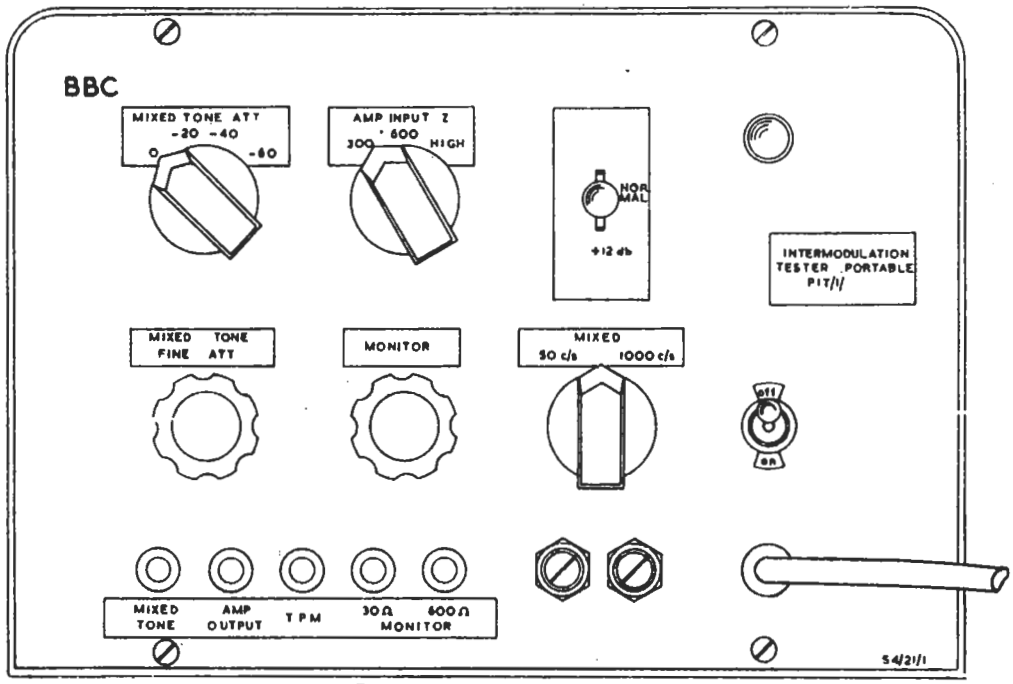

Fig. 16.1. PIT.1 Face Panel
Drawing No EK. 8453

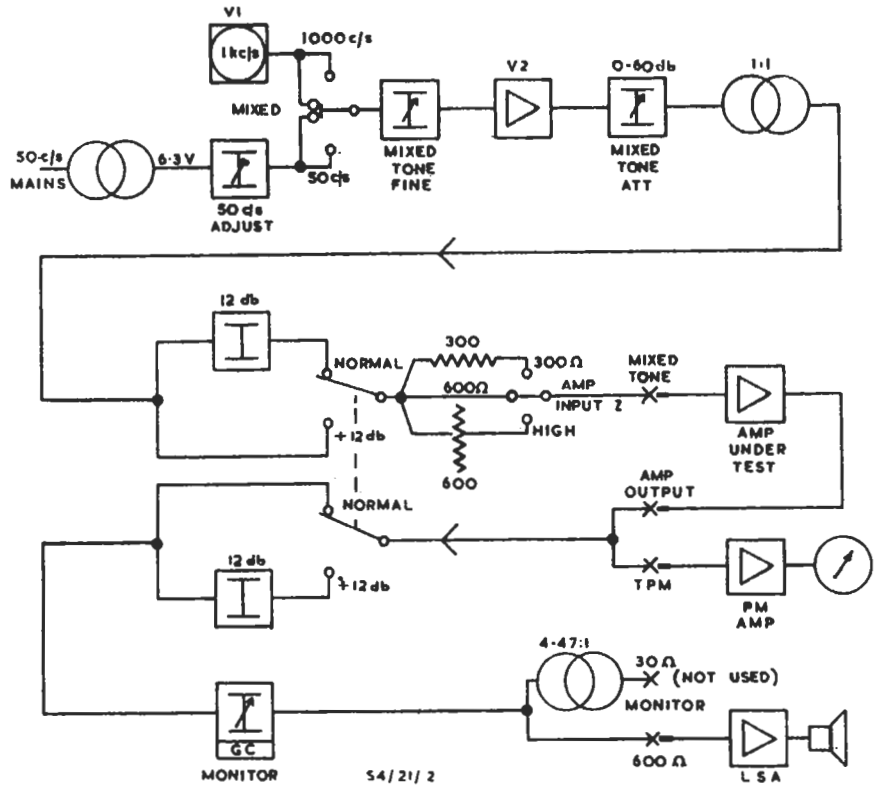

Fig. 16.2. Intermodulation Test Schematic Diagram

A two-bank switch SW A with contacts across R9 and the screen-to-cathode circuit of V1 allows either the 50-c/s or the 1-kc/s tone to be used alone if required. In the 1-kc/s position of the switch R9 is short-circuited, thus suppressing the 50-c/s signal, while in the 50-c/s position the screen-grid of V1 is connected directly to cathode, so preventing oscillation of the valve.

The slider of R11 is connected to the grid of V2, which operates as a mixed-tone amplifier in which distortion is kept low by voltage negative feedback applied to the cathode from the tertiary of transformer TR 1. Variation of R11 allows the output level from V2 to be adjusted over a range of about 25 db.

The secondary of TR 1 is taken to the *Mixed Tone Attenuator*, the loss of which can be switched to 0, 20, 40 or 60 db by means of SW B. The attenuator is followed by the 12-db loss-pad R22-R24, which can be short-circuited by a key. To obtain the full loss of 12 db from the pad for all positions of SW B, it is necessary to guard against the effects of longitudinal currents; for this reason a repeating-coil TR 2 is interposed between the attenuator and the pad.

Since amplifiers under test may have various input impedances, and both the 60-db attenuator and the 12-db pad are designed to operate into 600 ohms, an impedance-matching circuit is provided, comprising R29 and R30 controlled by SW C; three values of amplifier input impedance can be accommodated, 300 ohms, 600 ohms or *High*. With a 300-ohm amplifier, an additional 300 ohms series resistance is provided by R29; with a 600-ohm amplifier, a straight-through connection is made, while with a high-impedance amplifier a 600-ohm shunt resistance is provided by R30. The termination of the tester in each instance is thus effectively 600 ohms.

The input to the amplifier under test is taken from the *Mixed Tone* jack, and the amplifier output is returned to the *Amp. Output* jack, in parallel with which is a jack for a T.P.M. The wiring from these jacks is taken via additional contacts of the 12-db key which normally bridge a second 12-db pad, but bring it into circuit if the key is thrown. The signal then passes through the *Monitor Gain* control, R28, and via the 600-ohm *Monitor* jack to a loudspeaker amplifier or headphones. A further *Monitor* jack, intended for use with 30-ohm headphones, is fed via the impedance-step-down transformer TR 3.

The built-in power-supply unit incorporates a mains transformer TR 4 and two metal rectifiers with resistance-capacitance smoothing. A mains switch and fuses are provided, and a mains indicator-lamp is connected across the l.t. winding of TR 4, which also provides the 50-c/s test signal to R9.

Operating Procedure

Lining Up the Tester

1. Connect the *Mixed Tone* output jack to a TPM/3. As this has an input impedance of 10 kilohms, the *Amp. Input Z* switch on the tester should be set to *High*.
2. Turn the tone-selector switch to '1,000 c/s' and adjust the output level to a convenient value by means of the *Mixed Tone Fine* control and the *Mixed Tone Attenuator*.
3. Now turn the tone-selector switch to '50 c/s' and adjust the pre-set control inside the cover until the level as measured on the T.P.M. is 8 db below that at 1 kc/s.
4. Restore the tone-selector switch to the *Mixed* position.
5. With the 12-db key set to *Normal*, check that the tester is capable of delivering mixed tone at zero level without audible distortion.

Testing an Amplifier

1. Plug the *Mixed Tone* and *Amp. Output* jacks to the input and output respectively of the amplifier under test.
2. Turn the *Amp. Input Z* switch to the appropriate setting for the amplifier.
3. Set the tone-selector switch to *Mixed*. (The other positions of this switch are normally used only when calibrating the tester.)
4. Connect a loudspeaker amplifier or headphones to the 600-ohms *Monitor* jack. (The 30-ohms jack is for use only with special low-impedance headphones.)
5. With the 12-db key at *Normal*, adjust the mixed tone coarse and fine controls until the amplifier output with gain controls at usual settings is at line-up level measured on a peak-reading meter plugged into the T.P.M. jack.
6. Adjust the *Monitor Gain* control for a comfortable listening level.
7. Operate the key to the + 12-db position, and listen for a change in the quality of the 1-kc/s tone. (The ability to detect slight distortion on headphones can be increased by lifting them slightly from the ear.)

Note that since the input to the amplifier is increased by 12 db (i.e., to 4 db above peak programme level) the check for audible distortion is made at a higher level than the amplifier normally carries, so giving a 4-db margin in hand.

The procedure outlined above should be used for normal routine checks on amplifiers, studio desks and similar equipment.

If it is necessary to determine the actual level at which audible distortion occurs, the input should be adjusted until the distortion is just perceptible with the 12-db key operated, and the output level should then be measured at the T.P.M. jack. (When the output level is beyond the range of the meter, it should be measured with the key restored to *Normal*, and 12 db then added to the figure obtained.) The use of the PIT/1 as a measuring device is not, however, recommended, as there will be a certain amount of variation in the level at which different operators can detect distortion, although the instrument does give some idea of the safety margin available between normal peak volume and obvious overloading of the equipment under test.

General Data

Impedance

Normal load $Z = 300\ \Omega$, $600\ \Omega$ or *High*.

Mixed Tone Output Frequencies

1 kc/s $\pm 5\%$ (from oscillator) and 50 c/s (from mains).

NOTE.—50-c/s tone level 8 db below 1-kc/s level.

Mixed Tone Output Level

At least zero level without audible distortion when + 12 db key is at *Normal*.

Combination Tones

With + 12-db key operated, and a mixed-tone output level of + 12 db, the level of each combination tone (i.e., 950 c/s, 1,050 c/s, etc.), when measured on a harmonic bridge, should be at least 50 db below the level of the 1-kc/s tone.

Valve Data

Valve	*Heater Volts*	*Heater Amps*
Oscillator V1 : CV 138	6·3	0·3
Amplifier V2 : CV 138	6·3	0·3

Mains Supply

200-250 volts, 50 c/s a.c.

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