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IE-15A
Distortion Analyzer

Owner's Manual
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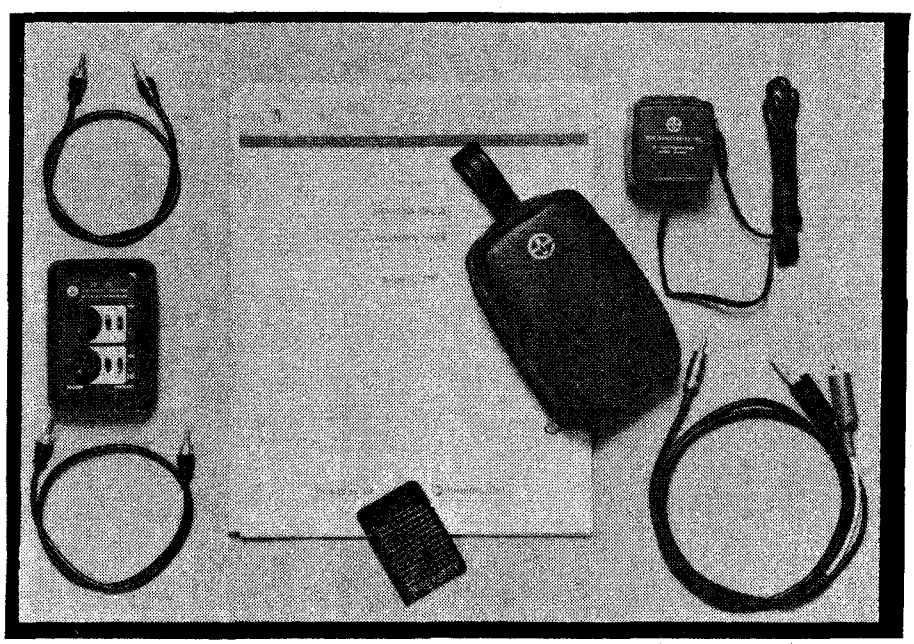
TABLE OF CONTENTS

INTRODUCTION

The measurement of audio system distortion is a task usually performed in the laboratory because of the typical bulk and cost of distortion measuring equipment. Ivie Electronics is dedicated to expanding laboratory capability to the field by designing professional audio equipment that is portable and innovative.

The IE-15A was designed to provide many years of accurate, trouble-free service. With your IE-15A you should have received the following standard accessories pictured in Figure 1 below:



THE IE-15A COMES WITH...

* *"Fast Charge" nickel cadmium batteries*
* *IE-165A AC adaptor/charger that provides continuous line operation*
* *IE-10A overlay screen*
* *Phono to clip lead input cable (3 ft)*
* *Two phono plug patch cords*
* *Vinyl carrying case with belt loop*
* *Operator's Manual with illustrations and examples*

Figure 1

We recommend that the Operator's Manual be studied thoroughly with emphasis on the "how to operate" portions of the manual. The maximum benefits will be received from ownership of an IE-15A when its features and functions are clearly understood.

Before the IE-15A is placed into service we suggest that the nickel cadmium batteries be charged for a 3 hour period, as the batteries may be partially discharged when the IE-15A is shipped from the factory. Make certain that the voltage selector switch, located in the base of the IE-165A Adaptor/Charger, is in the correct range for line voltages in your area.

THE IE-15A FRONT PANEL CONTROLS

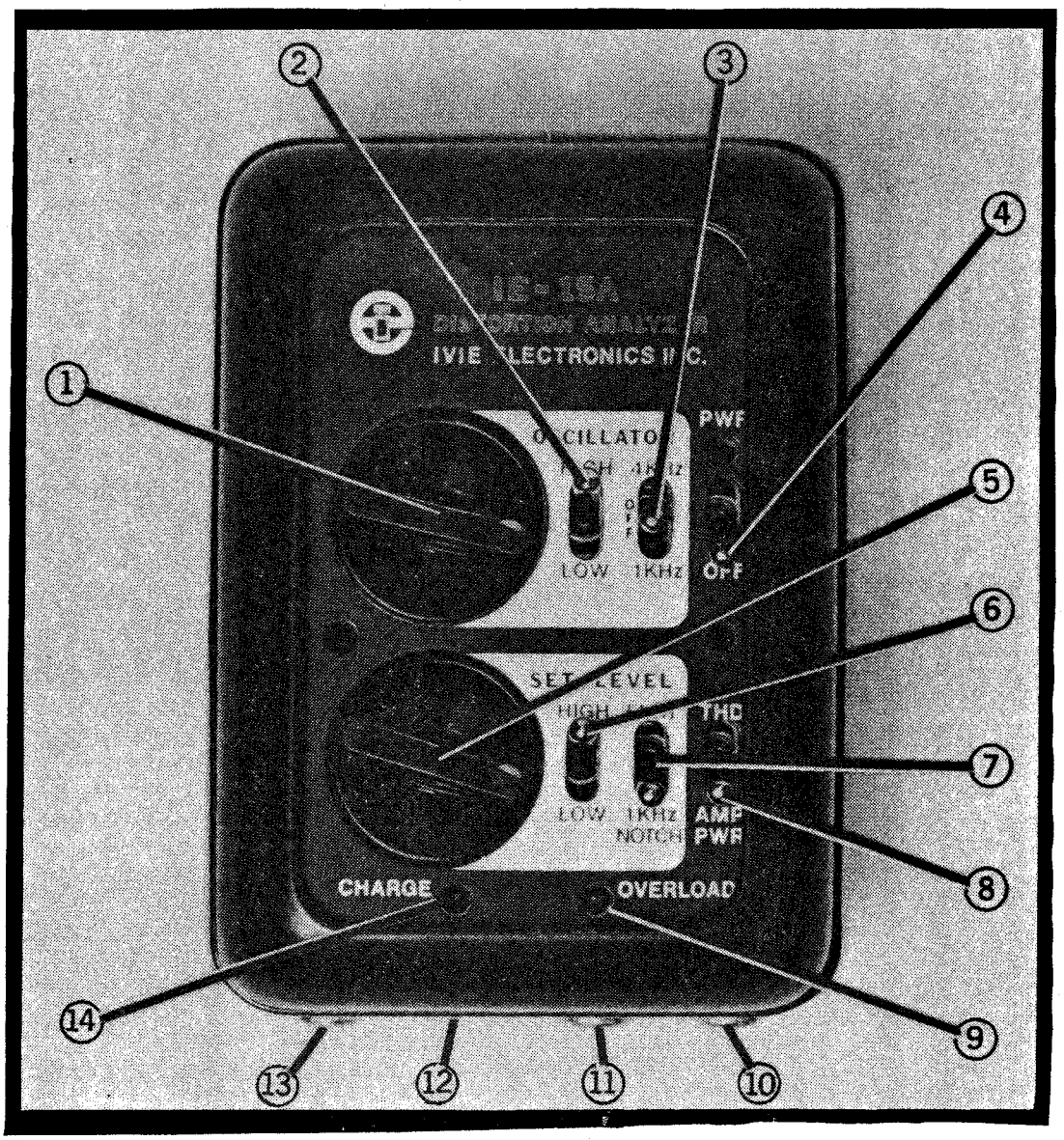


Figure 2

(1.) OSCILLATOR OUTPUT LEVEL VERNIER. Varies output level of the oscillator over a 30 dB range.

(2.) OSCILLATOR HIGH/LOW SWITCH. With this switch set to HIGH, the oscillator vernier 1 will adjust oscillator output levels over the range of 30mV rms to about 1.2 Vrms. The oscillator output range is attenuated 30 dB when this switch is placed in the LOW position. With the oscillator set to LOW level output, the vernier control 1 will adjust oscillator output levels over the range of 1 mV to 40 mV rms.

(3.) FREQUENCY SELECTOR SWITCH. Sets the output frequency of the IE-15A to either 1 KHz or 4 KHz. The IE-15A measures total harmonic distortion at the single frequency of 1 KHz. When this switch is in the center OFF position the oscillators are turned off, but the distortion analyzer circuitry in the IE-15A remains active. The OFF position is used when the oscillator is used in making signal-to-noise measurements.

(4.) POWER ON/OFF. Placing this switch in the PWR position applies power to all IE-15A circuits. A red LED, located at the top of the switch, indicates when the unit is turned on. Leaving this switch in the OFF position between measurements will extend the battery life between charges.

(5.) SET LEVEL VERNIER. Controls the input power level to the distortion analyzer over a 30 dB range. This vernier is used to set the reference level (REF) on the spectrum analyzer display.

(6.) SET LEVEL HIGH/LOW SWITCH. In the HIGH level position the IE-15A will analyze high power amplifiers with output voltages in the range of 3.0 Vrms to 100 Vrms. With the switch set to the LOW level position the IE-15A will analyze signals from 0.16 Vrms to more than 3.0 Vrms. More simply stated, high output power devices are measured with the switch set to HIGH, and low power devices with the switch set to LOW.

(7.) NOTCH FILTER CONTROL. When set to FLAT the passband of the IE-15A has a flat frequency response. The 1 KHz NOTCH setting rejects any 1 KHz energy in the distortion analyzer by more than 90 dB. Hum frequencies or harmonics are not attenuated, or affected by the notch filter.

(8.) THD/AMP PWR switch enables the operator to measure amplifier distortion (THD) or amplifier output power (AMP PWR) without rewiring the basic test setup of Figure 5.

(9.) OVERLOAD INDICATOR warns user of excessive signal input levels to the IE-15A that would cause inaccurate THD readings.

(10.) OUTPUT CONNECTOR for Ivie real time analyzer.

(11.) INPUT CONNECTOR to distortion analyzer section of IE-15A.

(12.) CHARGER RECEPTACLE for use with IE-165A AC Adaptor/Charger.

(13.) OSCILLATOR OUTPUT connector for IE-15A.

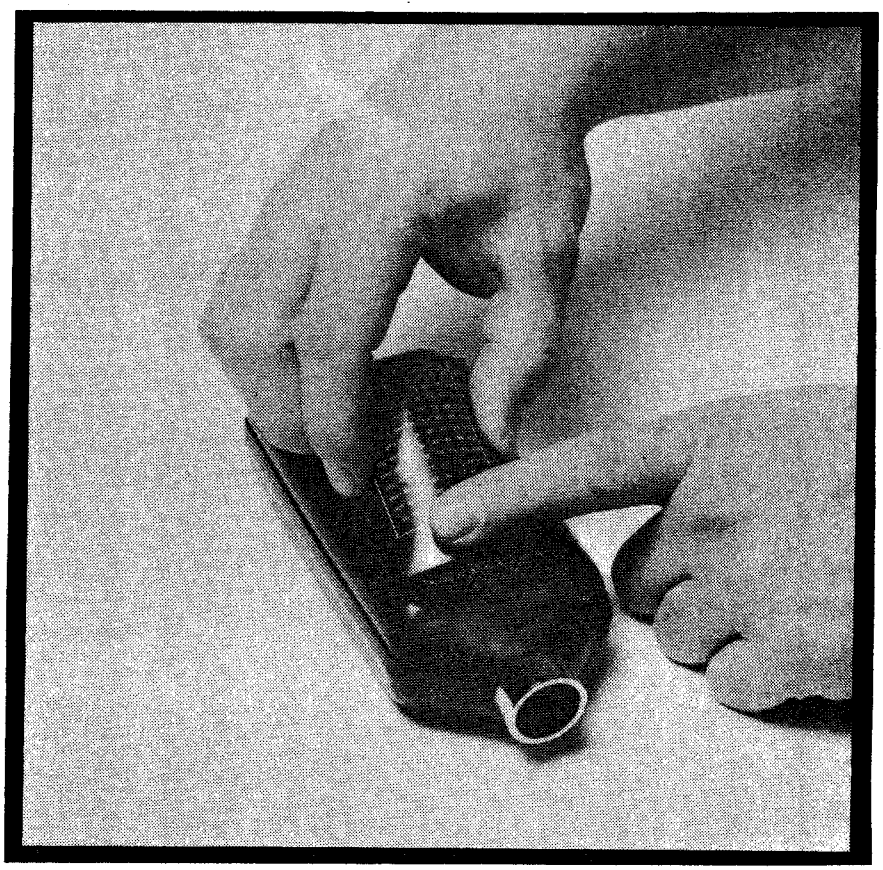
⑭ BATTERY STATUS INDICATOR has two important functions. It lights when the IE-15A is being charged, thus providing indication of a properly working battery charger. The LED also lights during battery operation when the batteries require charging.

USING THE IE-15A WITH THE IE-10A

INSTALLING THE IE-10A DISTORTION OVERLAY

A flexible plastic overlay is provided with the IE-15A for use with the IE-10A Spectrum Analyzer in making distortion measurements. The overlay directly converts all display readings to distortion: 1) as a percentage (%) of the 1 KHz test tone, or 2) in dB down from the test tone.

To install the distortion overlay into the IE-10A display window, place the IE-10A on a flat surface with controls facing "up". Holding the overlay between thumb and fingers (imprinted side "up") compress the overlay slightly and position it over the screen of the IE-10A as shown in Figure 3.



INSTALLING THE IE-10A OVERLAY

Figure 3

Using a finger from the opposite hand, press the top of the red plastic overlay flat against the IE-10A display screen, and slide the overlay toward the microphone of the IE-10A so that the overlay goes beneath the top rim of the IE-10A case. Next, allow the overlay sides to expand to full size, while directing them underneath the metal rim around the sides of the IE-10A screen. Use your fingers to orient the overlay in the window of the IE-10A so that the bottom edge of the overlay is resting against the top edge of the metal IE-10A nameplate. The overlay should not cover any portion of the metal nameplate. When properly aligned, the IE-10A will appear as Figure 4, and the 0 dB REF line of the distortion overlay will be positioned over the 0 dB line of the IE-10A screen.

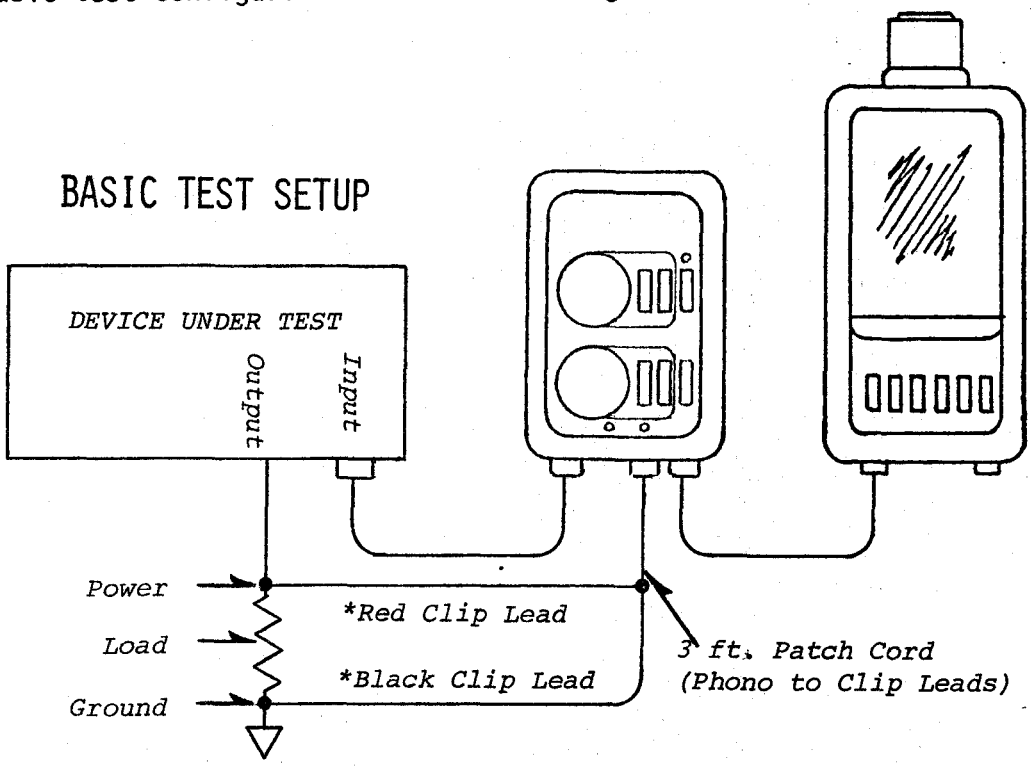
IE-10A WITH SCREEN OVERLAY INSTALLED

Figure 4

To remove the plastic overlay from the IE-10A screen use the "lift tab" provided at the bottom of the overlay.

THE BASIC TEST SETUP

The IE-15A was designed to simplify distortion measurements. Only one cable configuration is required to measure amplifier output power, output voltage, or total harmonic distortion (THD). Sufficient control range is provided in the IE-15A to measure amplifiers with output powers of a few milliwatts to amplifiers having hundreds of watts output power. The basic test configuration is shown in Figure 5.



** It is important to hook the red clip lead to the "power" side of the load, and the black clip lead to the ground side of the load. REVERSING POLARITY CAN DAMAGE YOUR IE-15A. To determine power vs. ground for an unknown wire pair, simply connect the red clip lead only to the wires, one at a time. The wire showing the higher signal level on your IE-10A is "power."*

Figure 5

The IE-15A, like other THD analyzers, does not contain the load impedances necessary to properly "terminate" a power amplifier. All power amplifiers need to be terminated with an impedance capable of absorbing the amplifier's total output power.

A purely resistive load (e.g. non reactive) represents the most perfect form of amplifier termination when measuring the rated output power, or THD. Using speakers to terminate an amplifier can present some potential measurement problems, and the following precautions are recommended to obtain accurate results:

1) Make certain that the speaker system is capable of handling the rated power output from the amplifier. Some audio systems, at full power, are capable of producing uncomfortable sound pressure

levels. Resistive loads are often easier on the ears.

2) The specified speaker impedance (e.g. 8 ohms) is normally an "average" of the speaker's impedances as they vary with frequency. Because amplifier output power is a function of the terminating impedance, it is not usually accurate to assume that any speaker has a constant impedance at all frequencies. The virtue of a purely resistive load is the constant impedance characteristic it has at all audio frequencies. When in doubt, use a resistive load.

3) Speakers can act like microphones. Amplifier distortion measurements, using speakers as the terminating element, may be inaccurate if the ambient room noises are suffiently loud as to superimpose room noises on the amplifier harmonics being measured.

4) Speakers have resonances, and they exhibit nonlinear characteristics that can produce harmonics. A THD measurement of an amplifier/speaker combination may exhibit a higher level of THD than the amplifier would have if measured alone using a resistive load. Again, when in doubt, use a resistive load.

MEASURING AMPLIFIER OUTPUT POWER OR VOLTAGE LEVELS

Most amplifiers have a specified THD for a given output power level, or range of output powers. To measure an amplifier's THD against the factory specification requires that we verify amplifier power output levels. The IE-10A is calibrated in dBm, and with the aid of conversion tables, power or voltage levels can be determined for any value of load impedance. A feature built into the IE-15A enables the user to determine amplifier power levels, and with the flip of a switch measure amplifier distortion levels, without any wiring changes to the basic test setup of Figure 5.

A very handy table that will provide rapid conversions between IE-10A readings, and power or voltage is shown in Figure 6.

dBm (600 ohms)	IE-15A/IE-10A AMP PWR TEST "dB"	EQUIVALENT OUTPUT Vrms	EQUIVALENT OUTPUT POWER (rms) Z_L = 4 ohms	Z_L = 8 ohms	Z_L = 16 ohms
+40 dBm	0	77.5 V	1502 watts	751 watts	375 watts
+39	- 1	69.0	1190	595	298
+38	- 2	61.5	946	473	236
+37	- 3	54.8	751	375	188
+36	- 4	48.9	598	299	149
+35	- 5	43.6	475	238	119
+34	- 6	38.8	376	188	94
+33	- 7	34.6	299	150	74.8
+32	- 8	30.8	237	119	59.3
+31	- 9	27.5	189	94.5	47.3
+30	-10	24.5	150	75	37.5
+29	-11	21.8	119	59.4	29.7
+28	-12	19.5	95	47.5	23.8
+27	-13	17.3	74.8	37.4	18.7
+26	-14	15.5	60	30	15
+25	-15	13.8	47.6	23.8	11.9
+24	-16	12.3	37.8	18.9	9.5
+23	-17	10.9	29.7	14.9	7.4
+22	-18	9.8	24	12	6
+21	-19	8.7	18.9	9.5	4.7
+20	-20	7.7	14.8	7.4	3.7
+19	-21	6.9	11.9	6	3
+18	-22	6.2	9.6	4.8	2.4
+17	-23	5.5	7.6	3.8	1.9
+16	-24	4.9	6	3	1.5
+15	-25	4.4	4.9	2.4	1.2
+14	-26	3.9	3.8	1.9	.95
+13	-27	3.5	3.1	1.5	.77
+12	-28	3.1	2.4	1.2	.6
+11	-29	2.7	1.8	.91	.46
+10	-30	2.4	1.4	.72	.36
+ 9	-31	2.2	1.2	.61	.30
+ 8	-32	1.9	.9	.45	.23
+ 7	-33	1.7	.72	.36	.18
+ 6	-34	1.5	.56	.28	.14
+ 5	-35	1.4	.49	.25	.12
+ 4	-36	1.2	.36	.18	90 milliwatts
+ 3	-37	1.1	.30	.15	80
+ 2	-38	1.0	.25	.13	60
+ 1	-39	.87	.19	95 milliwatts	50
0	-40	.78	.15	75	40
- 1	-41	.69	.12	61	30
- 2	-42	.62	96 milliwatts	48	24
- 3	-43	.55	76	38	19
- 4	-44	.49	60	30	15
- 5	-45	.44	48	24	12
- 6	-46	.39	38	19	10
- 7	-47	.35	31	15	8
- 8	-48	.31	24	12	6
- 9	-49	.28	20	10	5
-10	-50	.25	15.6	7.8	3.9

Figure 6

To measure amplifier power levels with the IE-15A and IE-10A system, connect the device under test to the IE-15A and IE-10A as illustrated in Figure 5 and initially set front panel controls as follows:

IE-15A: a) POWER----------On
b) OSCILLATOR-----output level is set wherever desired.
c) OSCILLATOR-----frequency 1 KHz.
d) MODE-----------AMP PWR
e) SET LEVEL------circuits are not functional in AMP PWR mode.

IE-10A: a) POWER----------On
b) MODE-----------OCT
c) SENSITIVITY----both switches 0 dB
d) DISPLAY--------resolution 1 dB/step
e) INPUT----------EXT (external)

Increase the sensitivity of the IE-10A until the 1K LED rises from the bottom of the screen to a position that is within the 11 dB measurement window of the distortion overlay. Add the values of the two sensitivity switch settings on the IE-10A to the dB reading on the distortion overlay. Note that all three numbers are prefaced by a "minus" sign. Next we refer to the conversion table of Figure 6, and locate in the AMP PWR TEST column (not dBm), the number of dB that you just measured using the IE-10A. From the same row in the table we can read the equivalent rms Voltage, dBm (600 ohms), or rms Power at 4, 8 or 16 ohms.

EXAMPLE 1

An amplifier having a load impedance of 4 ohms was measured with the IE-15A/IE-10A system. The sensitivity controls on the IE-10A were set to -10 and -0 dB respectively and the display reading was -3 dB as shown in Figure 7. What is the output power and the voltage?

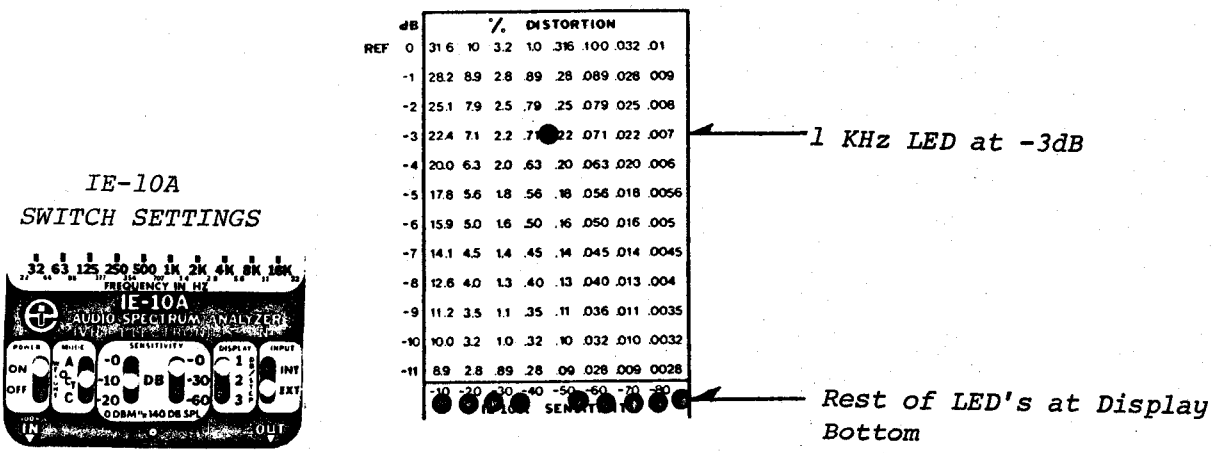


Figure 7

Adding the sensitivity control settings to the overlay reading we get:

$$(-10\ dB) + (-0\ dB) + (-3\ dB) = -13\ dB$$

From the table in Figure 6 a measurement of -13 dB is equivalent to 17.3 volts, or 74.8 watts across the 4 ohm load.

Knowing the rms voltage across any known impedance will enable us to calculate the rms power across that impedance using the following equation:

$$P_L = \frac{(Vrms)^2}{Z_L}$$

P_L = rms power in the load

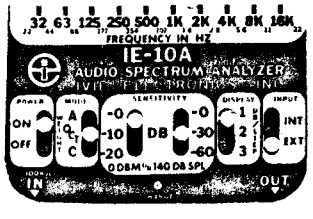
Vrms = rms voltage across the load

Z_L = load impedance.

e.g. $P_L = \frac{(17.3)^2}{4} = 74.8$ watts (Previous example)

EXAMPLE 2

An amplifier having an unknown load impedance was measured with the IE-15A/IE-10A system. The sensitivity controls on the IE-10A were set to -0 dB and -30 dB respectively, and the display reading was -4 dB as shown in Figure 8. What is the output voltage and the output power?



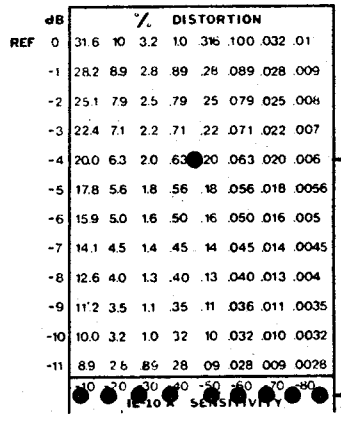


Figure 8

The displayed value on the IE-10A is (-0 dB) + (-30 dB) + (-4 dB) = -34 dB. Referring to the table of Figure 6, -34 dB AMP PWR TEST is equivalent to 1.5 volts. We are not given the amplifier load impedance, and therefore cannot determine the output power.

PRESETTING AMPLIFIER POWER OR VOLTAGE LEVELS

The previous manual section dealt with determining the output power, or voltage levels of amplifiers. It is recommended that you read the previous section if you have not already done so. This section will deal with setting amplifier output power, or voltage to a desired level.

To preset amplifier power or voltage levels, initially set front panel controls as follows:

IE-15A:
a) OSCILLATOR-------LOW
b) OSC VERNIER------Full counterclockwise
c) FREQUENCY--------1 KHz
d) POWER------------ON
e) MODE-------------AMP PWR

Note: SET LEVEL controls are inoperative in the AMP PWR mode.

IE-10A:
a) POWER------------ON
b) MODE-------------OCT
c) SENSITIVITY------both switches 0 dB
d) DISPLAY----------resolution 1 dB/step
e) INPUT------------EXT (external)

Connect the IE-15A/IE-10A system to the amplifier to be tested re the basic test configuration of Figure 5. Don't forget to terminate the amplifier into a suitable load impedance.

In order to preset an amplifier power level you must know the factory specified output power and the load impedance. With these two numbers, you are prepared to refer to the table of Figure 6 to find the equivalent AMP PWR TEST level in dB.

An example will more effectively describe the method.

EXAMPLE 1

Assume that you need to test an amplifier with a factory specified output power of 50 watts into a 4 ohm load. Determine what the IE-10A display reading will be for a 50 watt amplifier output.

Referring to the table of Figure 6 the closest power reading to the desired 50 watts at 4 ohms is 47.6 watts, with the 1.0 dB resolution of the IE-10A. The AMP PWR TEST level that correlates with 47.6 watts at 4 ohms is -15 dB. To achieve this power level, preset the IE-10A sensitivity controls to -10 and -0 dB respectively. The next objective is to increase the level of IE-15A oscillator signal going to the test amplifier until a -5 dB level is reached on the IE-10A display.

Having initially set the IE-15A oscillator to LOW level output, and the oscillator vernier to its minimum output position (full counterclockwise) rotate the vernier clockwise to increase the signal drive level to the amplifier under test. If the oscillator vernier arrives at the full clockwise position before the amplifier reaches the power output level desired, rotate the oscillator vernier to its full counterclockwise position, and shift the oscillator output to the HIGH level position. As before, increase the oscillator vernier until the desired IE-10A reading is obtained. The method described above to adjust the IE-15A oscillator output level is used as a precautionary measure to prevent overdriving the amplifier under test.

In the above example, the IE-10A sensitivity controls were preset at -0 dB, and -10 dB, and the display was adjusted to a level of -5 dB using the oscillator vernier control of the IE-15A. Adding the sensitivity control settings with the display reading we get: (-0 db) + (-10 dB) + (-5 dB) = -15 dB, or 47.6 watts into a 4 ohm load.

With amplifier power set to the specified, or desired output level, we would be able to measure signal-to-noise ratios, THD, and other important amplifier parameters.

MEASURING THD

Before attempting to measure THD, all previous material in section 3 should be read. The IE-15A, IE-10A, and the amplifier to be tested should be configured as per the basic test setup of Figure 5.

Step 1. Preset the amplifier output power, or voltage as described previously in this section. Once the IE-15A oscillator has been adjusted for the desired amplifier output levels, do not adjust the oscillator controls again until the THD measurement is completed. Oscillator should have been set to a frequency of 1 KHz.

Step 2. Make the following changes to the front panel controls of the IE-15A, and the IE-10A.

```
IE-15A:  SET LEVEL vernier----full counterclockwise
         SET LEVEL------------HIGH
         SET LEVEL------------FLAT
         MODE-----------------THD

IE-10A   MODE-----------------OCT
         SENSITIVITY----------both switches 0 dB
```

Setting the IE-10A to the octave bandpass filter mode of operation allows the measurement and calibration of the fundamental test tone at the output of the amplifier under test, while rejecting the harmonics and the hum components. See the manual section titled THEORY OF HARMONIC DISTORTION MEASUREMENTS for additional information.

You are now prepared to calibrate the IE-15A using the SET LEVEL vernier control. Rotate the vernier slowly clockwise until the 1 KHz LED on the IE-10A screen is centered on the 0 dB REF (reference) line as shown in Figure 9. If rotating the IE-15A SET LEVEL vernier fully

clockwise does not bring the 1 KHz LED to the REF line on screen, reset the vernier to the full counterclockwise position, change the SET LEVEL toggle from HIGH to LOW, and calibrate the system as described previously. Rotate the SET LEVEL vernier until the 1 KHz is centered over the 0 dB reference line.

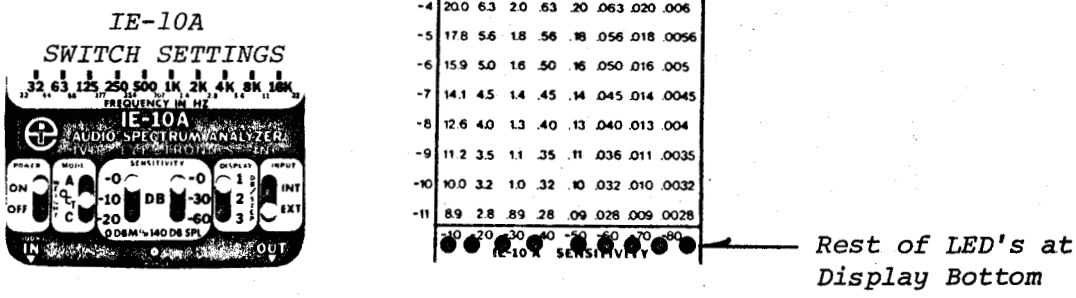


Figure 9

The IE-15A/IE-10A THD system is now calibrated. Make the following instrument control changes:

IE-15A: SET LEVEL-------1 KHz NOTCH

By selecting the 1 KHz notch filter, the test signal fundamental has been reduced by 90 dB, leaving only the amplifier harmonics in the distortion analyzer. We are now prepared to measure the harmonic output of the amplifier under test.

IE-10A: MODE-------"A" weight filter if it is desired to exclude hum components from the measurement of harmonics. The "A" weight filter reduces 50-60 Hz energy by more than 25 dB, but does not attenuate the harmonics.

MODE-------"C" weight filter if it is desired to include the hum components with the harmonics in the distortion test. There is negligible attenuation of the harmonics or the 50-60 Hz hum components when using the "C" weighted filter.

Begin to increase IE-10A SENSITIVITY in 10 dB steps until the row of LEDs rise from the bottom of the screen to a level inside the distortion overlay measurement window. See figure 10.

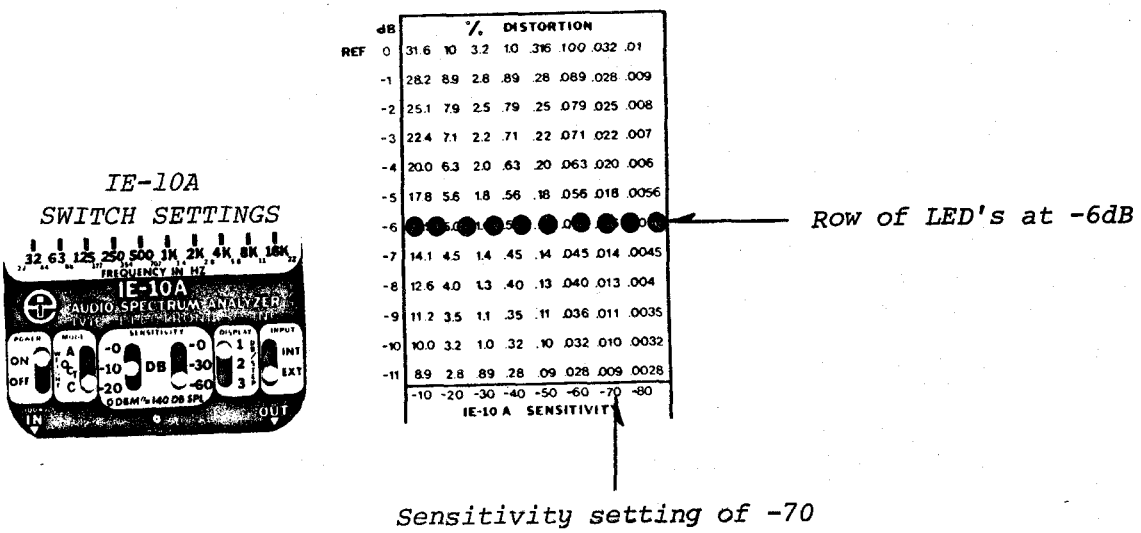


Figure 10

The distortion level (THD) is now easily determined:

1) add the two IE-10A SENSITIVITY switch settings together.

2) find the same total SENSITIVITY number along the baseline of the IE-10A distortion overlay, labeled IE-10A SENSITIVITY. (Figure 10). The column of numbers located above the SENSITIVITY setting on the distortion overlay represent all the possible % DISTORTION readings for that particular decade of SENSITIVITY.

3) the % DISTORTION reading that is intercepted by the row of LEDs and the number column above the SENSITIVITY setting is the correct value of THD for that given measurement setup.

An example will clarify the proceedure.

EXAMPLE

IE-10A SENSITIVITY switches are set to 0 dB and -60 dB respectively and the row of LEDs on screen are located at a position that is 3 dB below the reference line (REF) on the distortion overlay as shown in Figure 11. What is the THD level as a percentage, and also in dB below the fundamental?

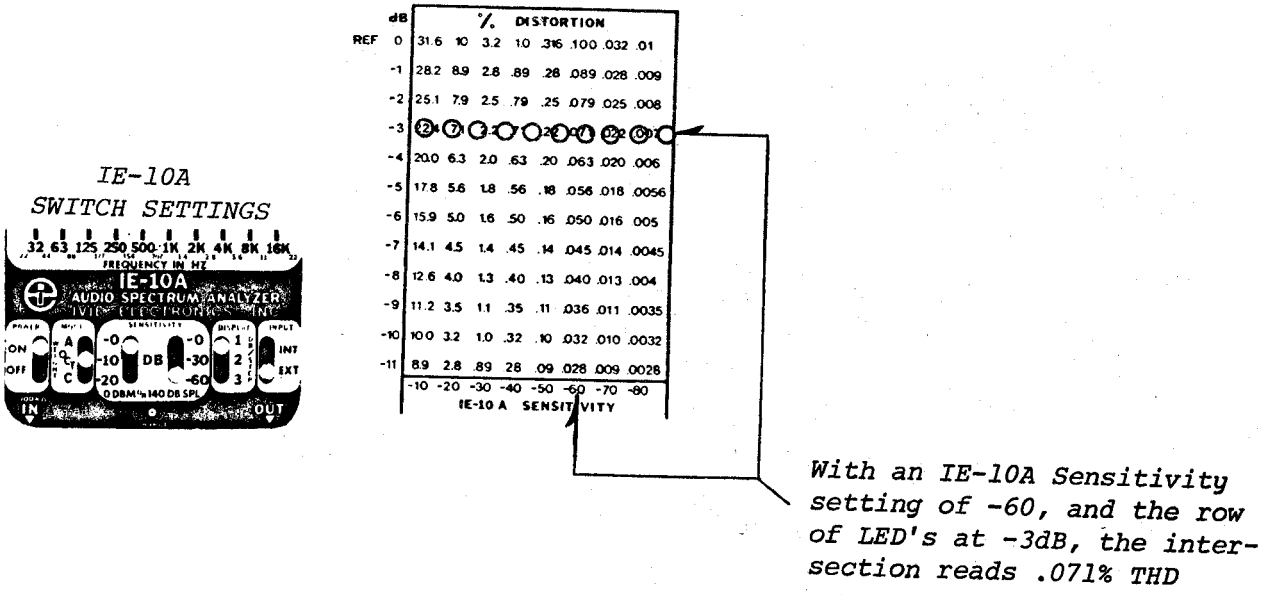


Figure 11

Adding the two IE-10A SENSITIVITY switch settings of 0 dB, -60 dB we obtain -60 dB. The % DISTORTION intercept of the row of LED's and the total SENSITIVITY is shown in Figure 11. The correct reading is a THD level of .071%.

To measure how many dB down, the THD is from the fundamental simply add the total SENSITIVITY setting to the number of dB the LEDs are down from the reference line (REF) on screen. For this particular example, THD is -63 dB, or 63 dB below the fundamental.

Once the system is calibrated to measure THD, the IE-10A MODE switch can be changed between "A", "OCT", or "C" without upsetting the calibration adjustments. This feature provides the capability to quickly compare amplifier THD's with or without hum. If there is a significant increase in the THD level measured as IE-10A MODE is switched from "A" to "C" you may wish to investigate the amplifier under test for excessive hum, or low frequency noise problems. If the IE-10A is switched to the octave (OCT) mode, the low frequency hum and noise components can be analyzed and measured.

THE IE-15A AS A SIGNAL GENERATOR

The oscillator in the IE-15A is an ultra pure generator capable of producing tones at 1 KHz and at 4 KHz. Using the IE-15A as a sinewave generator involves only four of the front panel controls:

1) POWER OFF/ON
2) FREQUENCY SELECTOR (1 KHz or 4 KHz)
3) OSCILLATOR HIGH/LOW (30 dB fixed attenuator)
4) OSCILLATOR VERNIER (30 dB variable attenuator)

Output voltage levels of the IE-15A can be adjusted from approximately 1.1 volts to less than 1.0 millivolt; an adequate range for most applications. When specific output voltage levels are desired, the IE-15A can be used with a spectrum analyzer to adjust the sinewave signal to a precise level.

Voltage output levels of the 1 KHz and 4 KHz tones are the same. If the 1 KHz tone is adjusted to a particular output level, the 4 KHz tone will have the same amplitude. Output impedance of the generator is a constant 50 ohms.

VERIFYING RESIDUAL DISTORTION OF IE-15A

All electronic products exhibit some finite level of distortion, including the circuitry of distortion analyzers like the IE-15A. For obvious reasons, the distortion created within a distortion analyzer must be less than the lowest distortion level the system is intended to measure. To be more specific, the IE-15A could not accurately measure distortion levels of .01% if its own internal distortion were equal to or greater than .01%. Typically, it is desireable to have the internal distortion levels of a distortion analyzer several dB below the smallest distortion level to be measured.

TEST SETUP FOR VERIFYING RESIDUAL DISTORTION OF THE IE-15A

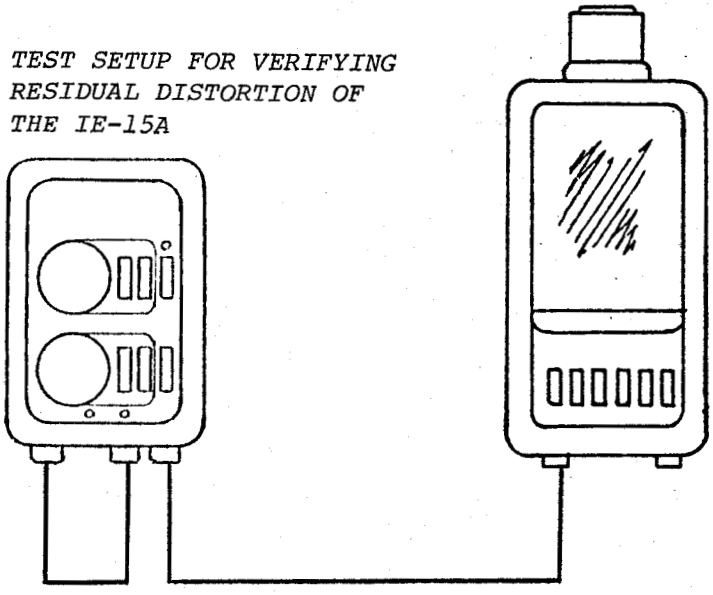


Figure 12

Verifying where the residual distortion levels are in the IE-15A is a fairly simple task using an IE-10A. Connect the IE-15A to the IE-10A as shown in Figure 12 on the preceeding page.

Make the following front pannel settings:

IE-15A: OSCILLATOR----------HIGH
OSCILLATOR----------full clockwise
OSCILLATOR----------1 KHz
SET LEVEL----------LOW (most sensitive)
SET LEVEL----------pointer at 12 o'clock
SET LEVEL----------FLAT
MODE----------THD
PWR----------ON

IE-10A: PWR----------ON
MODE----------"A" weight
SENSITIVITY----------both toggles at 0 dB
DISPLAY----------1 dB/step
INPUT----------EXT

Adjust the SET LEVEL vernier on the IE-15A to bring the display lights of the IE-10A to the 0 dB reference line on the distortion overlay.

Change the IE-15A SET LEVEL switch from FLAT to 1 KHz notch.

Change the IE-10A SENSITIVITY toggles from the 0 dB settings to -20 and -60 dB respectively (max gain).

A properly working IE-15A should have residual distortion levels that are less than .01% (typically .005%). If distortion levels are not less than .01%, recheck the test setup for loose cables or improper control settings. Any IE-15A's that exhibit high residual distortion levels should be sent to an IVIE repair center.

The spectrum analyzer can be eliminated as a potential cause of any apparent distortion problems if the input cable to the IE-10A is disconnected from the IE-15A and the resulting display observed. The display lights in the IE-10A should fall to the bottom of the screen. The noise floor in a normal IE-10A Spectrum Analyzer is 20 dB below IE-15A residual levels and therefore does not contribute residual errors in making THD measurements.

THEORY OF HARMONIC DISTORTION MEASUREMENTS

In theory, a distortionless amplifier is one which perfectly amplifies, and duplicates the input signal without additional signal coloration. If a pure sinewave is fed into a "perfect" amplifier, the sinewave will be amplified, but no additional frequency components will appear in the amplifier output, as shown in Figure 13.

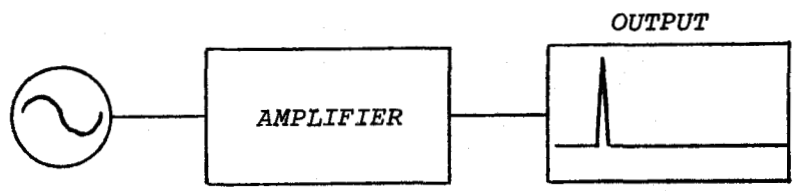


Figure 13

But in the absence of perfect amplifiers and transducers, the acoustics industry must contend with distortion in audio systems. A more typical amplifier would amplify the pure tone, but would also create a few additional harmonics due to amplifier nonlinearities. See Figure 14.

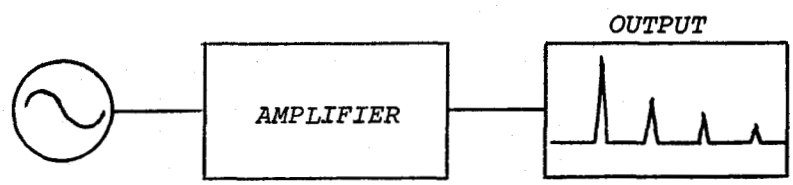


Figure 14

Basically, a distortion measurement consists of taking the ratio between the rms sum of the harmonics E_2 - E_n, and the fundamental E_1. Mathematically, distortion "D" is expressed as:

$$D = \frac{\sqrt{E_2^2 + E_3^2 + E_4^2 \ldots + E_n^2}}{E_1}$$

where:

D = percent distortion

E_1 = voltage of the ultra-pure oscillator tone (fundamental) measured at the output of the amplifier under test.

E_2 to E_n = voltage levels of the harmonic distortion components as measured at the output of the amplifier under test.

The purpose of a distortion analyzer is to electrically separate the fundamental E_1 from the harmonics E_2 - E_n, so that the relative amplitudes can be measured. The fundamental's amplitude E_1 can be measured, and isolated from the harmonics using the bandpass filters in the Ivie spectrum analyzer. A notch filter in the IE-15A will reduce the fundamental E_1 by more than 90 dB, allowing measurement of the harmonics alone. The Ivie THD system translates these measured levels into percent distortion, or distortion in dB below the fundamental.

BATTERY CARE AND LINE OPERATION

An IE-165A AC Adaptor/Charger has been supplied with your IE-15A Distortion Analyzer that will recharge the batteries in about 3 hours. The IE-15A will operate approximately 12 hours between charges.

When the "CHARGE" LED lights, indicating low batteries, recharging is immediately necessary. The IE-15A specifications cease to be accurate shortly after this LED illuminates.

CAUTION: Use of an AC adaptor/charger other than the IE-165A may cause damage to your IE-15A.

The IE-165A AC Adaptor/Charger is selectable for voltages of 115 or 230 VAC at 50 to 60 Hz. Make sure the voltage switch on the IE-165A is in the correct position for the AC power line being used. Using the IE-165A with AC power other than 115v. or 230v. at 50-60Hz. may cause damage to your IE-15A.

The IE-15A may also be operated directly and continuously from the AC power line using the IE-165A as an adaptor. It should be noted, however, that power line noise will limit distortion measurements to 0.5% while the IE-15A is being charged. The Ni-Cad batteries will continue to charge when the analyzer is being operated in this manner.

The Ni-Cad batteries in the IE-15A are of the highest quality and are capable of withstanding extended overcharging. It is recommended that they be completely discharged (until the "Charge" LED on the IE-15A illuminates) from time to time to minimize the possibility of "memory effect" in the batteries. Ni-Cad batteries can lose their ability to give up 100% of their charge if they are only partially discharged on a frequent basis.

If permanent power line operation of the IE-15A is desired, it is recommended that the Ni-Cad batteries be removed and that a line operated DC power supply of 6v. and 50ma be provided in their place. The external power supply can be conveniently provided to the IE-15A through the charge jack 12 (Figure 2) (center pin is positive.)

IE-15A SPECIFICATIONS

DISTORTION ANALYZER

* Measures distortion .01% to 100% in 9 ranges.
* 80 dB distortion range for inputs from 0.16 Vrms to 100 Vrms.
* Accuracy ± 1 dB.
* Input overload indicator.
* Fundamental rejection is $>$ 90 dB @ 1 KHz.
* IE-15A instrument distortion typically $<$ .005% @ 1 KHz.
* Input impedance 100k ohms shunted by $<$ 20pf.
* Selectable high-pass filter has 60 Hz rejection of 25 dB.

OSCILLATOR

* Selectable 1 KHz or 4 KHz tones.
* Frequency accuracy ± 5%.
* Output level adjustable from 1.0 Vrms to 1.0 mVrms.
* Harmonics 85 dB down @ 1KHz.
  65 dB down @ 4KHz.
* 50 ohm constant output impedance.

POWER

* BATTERY OPERATION: rechargeable nickel cadmium.
* Operating time approximately 12 hours continuous @ 25 C.
* Fast charge cycle of 3 hours.
* Low battery indicator light.
* AC LINE OPERATION from AC adaptor/charger
* 115/230 VAC 50/60 Hz.
* Charge indicator light.

ENVIRONMENTAL

* All circuits temperature compensated.
* Operating Temp. -10^{0} C. to $+50^{0}$ C.
* Nonoperating Temp. -30^{0} C. to $+65^{0}$ C.
* Operating Humidity 1 to 90%

MECHANICAL

* Aluminum case fusion bonded with nylon.
* Dimensions (wxhxd) 69 92 39 mm. (approx. 2 3/4 x 3 5/8 x 1 5/8 in.)
* Weight net 285 gms (approx. 10 oz)
  shipping 800 gms (approx. 1 3/4 lbs.)

ARCHITECT'S AND ENGINEER'S SPECIFICATIONS

The Distortion Analyzer and Oscillator shall be battery operated using fast-charge nickel cadmium batteries. The analyzer shall operate not less than 12 hours between charges, and the unit shall have a low battery and charge indicator. The analyzer shall be capable of direct operation from line voltages of 115v. and 230v. AC at 50-60Hz.

The Distortion Analyzer and Oscillator dimensions shall be approximately 69x92x39 mm, and the analyzer chassis shall be aluminum, fusion bonded with nylon.

The Distortion Analyzer and Oscillator shall generate puretone signals at 1KHz and 4KHz with a frequency accuracy of $\pm$ 5% at an output level selectable between 1.0mVrms and 1.0Vrms.

The Distortion Analyzer and Oscillator shall be compatible with the IE-10A and IE-30A Audio Spectrum Analyzers, and with either analyzer, it shall be capable of measuring THD from 100% to .01%, using a 1KHz C W signal. Fundamental rejection of the Distortion Analyzer shall be at least 90 dB @ aKHz and its internal distortion shall be $\leq$ .005%.

The Distortion Analyzer and Oscillator shall be the IE-15A Distortion Analyzer and Oscillator manufactured by IVIE ELECTRONICS INCORPORATED.

SERVICE AND WARRANTY

SERVICE

It is the intention of Ivie Electronics to provide quality service for the IE-15A whether in or out of the warranty period. If the IE-15A should require service, please return it shipping prepaid to an Ivie Electronics service facility. Shipping the instrument in its original packaging is recommended. Repair will be made and the unit will be returned prepaid as soon as possible.

Due to the subminiaturized packaging techniques used, Ivie Electronics cannot assume responsibility for repairs made at other than an authorized service center.

WARRANTY

The IE-15A is warranted against defects in materials and workmanship for one (1) year from the date of purchase. During the warranty period Ivie Electronics will repair, or at its option, replace components which prove to be defective provided the analyzer is returned shipping prepaid to an authorized Ivie Electronics service facility. Defects caused by modifications, misuse or accidents are not covered by this warranty. No other warranties are expressed or implied. Ivie Electronics is not liable for consequential damages. All requests for repairs and information should include the instrument serial number to assure rapid service.

NOTES

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