Intermodulation Measurements on Radiotron Amplifier A515

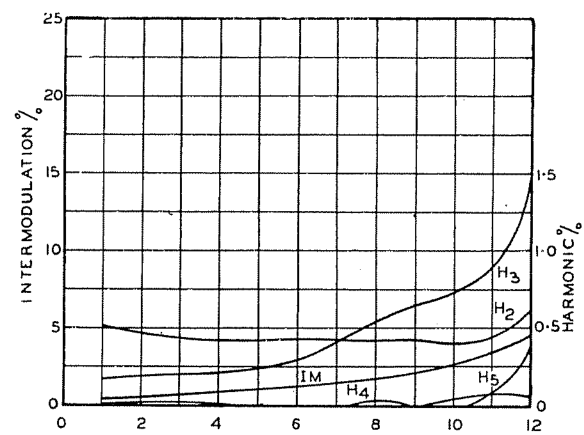
By R. H. ASTON, A.M.I.R.E. (Aust.).

When the Radiotron high fidelity amplifier A515 was described in Radiotronics 128, intermodulation tests were not included because suitable measuring equipment was not available at that time. An Altec Lansing signal generator type T1 401 and intermodulation analyzer T1 402 were subsequently purchased and intermodulation measurements made as published below.

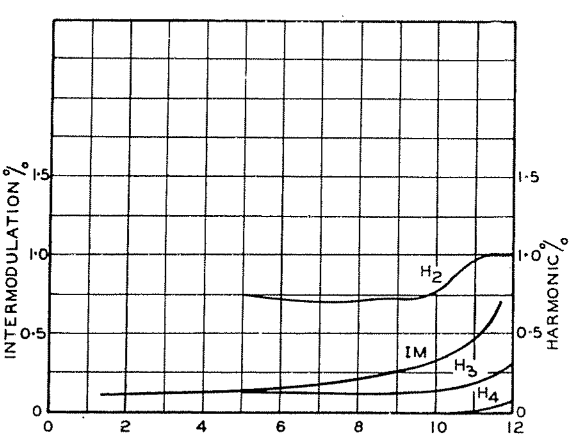
As a guide to the amount of intermodulation which is tolerable, Hilliard states that less than 2 per cent. cannot be detected by ear. It is further claimed that this method of measuring distortion is a very sensitive one and agrees well with the aural impression of distortion. For those readers who require additional information on the subject of intermodulation testing we publish below a bibliography of some of the articles which have appeared in the literature.

Measurements were made of intermodulation and individual harmonics present for various output powers both with and without feedback. These results are published so that some indication of the correlation between intermodulation and harmonic analysis may be obtained.

It should be noted that the intermodulation tests show overload conditions for a lower power output than that indicated by the harmonic measurements of a single frequency input. This arises from the fact that distortion occurs with high peak voltages rather than high powers. When two input signals are applied simultaneously and one of them is four times the amplitude of the other, the smaller signal makes a negligible contribution to the power output, but adds directly to the peak voltage amplitude. As the waveform of the signals encountered in practice is generally of a complex nature, the overload indicated by intermodulation tests is a more practical one.



OUTPUT WATTS WITHOUT FEEDBACK
IM PLOTTED FOR EQUIVALENT POWER OUTPUT.



OUTPUT WATTS NORMAL FEEDBACK.
IM PLOTTED FOR EQUIVALENT POWER OUTPUT.

The only change in the amplifier was the replacing of the output transformer by one designed and manufactured for this amplifier by Fergusons Radio. With the new transformer the amplifier was even more stable than with the Goodmans transformer used previously.

The input signal consisted of the simultaneous application of a 60 c/s sine wave and a 2,000 c/s sine wave. The 2,000 c/s signal was 12 db lower than the 60 c/s input. The combined signals passed through the amplifier and to the intermodulation analyzer where the 60 c/s fundamental was filtered out. The 60 c/s sideband components of the 2,000 c/s, considered as a carrier, were then measured and expressed as a percentage modulation factor.

The output power was calculated from a measurement of the rms voltage, due to the two signals, developed across a 10 ohm resistance.

So that a closer practical comparison can be made between the intermodulation measurements and the harmonic analysis, it is better to calculate the equivalent power output which would result from a single sine wave signal having the same peak amplitude as the sum of the peak voltages of the two signals used for the intermodulation tests. The intermodulation distortion resulting with this equivalent power output can then be compared with the harmonic distortion resulting with the actual power output from a single sine wave.

The equivalent power output may be derived as follows:

let E_1 = 2,000 c/s output voltage
E_2 = 60 c/s output voltage
E_T = measured rms total of E_1 and E_2

that is $E_T = \sqrt{E_1^2 + E_2^2}$

$E_2 = 4E_1$ since E_1 is 12db below E_2

$$\therefore E_T = E_1\sqrt{1+16} = E_1\sqrt{17}$$

$$\text{and} \quad E_1 = \frac{E_T}{\sqrt{17}}$$

$$E_2 = \frac{4E_T}{\sqrt{17}}$$

$$E_1 + E_2 = \frac{5}{\sqrt{17}} E_T$$

Equivalent power output =

$$\frac{\left(\frac{5}{\sqrt{17}} E_T\right)^2}{R_L} = \frac{25}{17}\,\frac{E_T^2}{R_L}$$

MEASUREMENTS

Output watts	Equivalent Output watts	Intermodulation per cent. normal	Intermodulation per cent. no feedback
1.0	1.47	0.10	0.27
2.0	2.94	0.11	0.37
3.0	4.42	0.13	0.69
4.0	5.88	0.17	1.20
5.0	7.35	0.22	1.65
6.0	8.83	0.27	2.15
7.0	10.30	0.35	2.8
8.0	11.78	0.72	4.3
9.0	13.24	1.75	7.2
10.0	14.71	3.70	11.0
11.0	16.18	7.2	17.5
12.0	17.65	8.8	23.2
13.0	19.12	14.5	29.0
14.0	20.59	22.0	34.0
15.0	22.2	26.0	35.0

HARMONIC ANALYSIS

60 c/s output into 10 ohm resistive load. No feedback.

Output watts	Harmonics per cent. H_2	H_3	H_4	H_5
1.0	0.52	0.17	—	0.025
3.0	0.44	0.22	0.02	—
5.0	0.41	0.24	—	0.025
6.0	0.42	0.29	—	0.02
7.0	0.42	0.40	—	0.04
8.0	0.42	0.54	0.02	0.05
9.0	0.42	0.65	—	0.05
10.0	0.40	0.72	0.04	0.055
11.0	0.43	0.88	0.07	0.07
12.0	0.62	1.48	0.06	0.35
Oscillator	0.66	0.06	—	0.025

60 c/s output into 10 ohm resistive load. Normal feedback.

Output watts	Harmonics per cent. H_2	H_3	H_4	H_5
5.0	0.75	0.11	—	0.025
7.0	0.73	0.13	—	0.025
8.0	0.73	0.14	—	0.025
9.0	0.73	0.14	—	0.025
10.0	0.73	0.16	—	0.025
11.0	1.0	0.18	—	—
12.0	1.0	0.30	0.04	0.05
Oscillator	0.73	0.07	—	0.025

REFERENCES

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