Letters to the Editor

INDUCTOR STANDARDIZATION?

May I put in a plea for the humble inductor?

In various journals over the past few years I have noted with increasing despair phrases such as: " ... inductors have been avoided ...", "... coil-less design ...", "... simulated inductor ...", " ...RC active filters ..." Anyone would think you could catch rabies if you used a coil/inductor.

Maybe the root of the problem is that coils are essentially customized things, not much given to standardization in the form of resistors, capacitors etc. However, if you ever read our advertisements, you will see that we have been trying to establish the fact that we supply coils of a broadly standard nature.

Nevertheless, I wonder if your readers could be asked to provide their own ideas of a basis of standardization of the range for general purposes. I feel confident that a basic set of standards could thus be drawn up and publicised, so that designers need not have to fuss over absurdities like " 49t 0.28mm wire on a Mullard Vinkor LA1157 (260μH)".

So rather than waste time and effort rolling your own (whoever wound their own resistors from bits of resistance wire?), let's establish the humble coil as a bona fide stock component so that designers design circuits, not components.

William Poel,
Ambit International,
Brentwood,
Essex.

INTERFERENCE FROM AMATEUR STATIONS

We have noted that in your March issue the first part of the RSGB interference survey report is published in its original form. The RSGB has been represented at a number of our Interference Sub-Committee meetings, and at the last of these (when the report was considered) it was emphasised that receiver manufacturers have a very clear and sympathetic understanding of the technical and social problems involved.

As mentioned in the report, there is an established procedure for dealing with this sort of interference, and the fact that receiver manufacturers get so few complaints suggests two things. Firstly, that the amateurs concerned are taking what action they can to alleviate the situation, and this co-operation is gratefully acknowledged. Secondly, that the procedure whereby the Post Office notifies the appropriate manufacturer of an unresolved case of interference is often not being invoked.

As with any instance of interference, a balance has to be struck between conflicting aspects, but in this case the "neighbour-relations" add a particularly sensitive factor. On the one hand the amateur has the right to operate his equipment within the conditions of his licence, and on the other hand the viewer or listener also has the right to expect interference-free reception provided that his equipment is supplied with an adequate signal from an efficient aerial system.

There is no simple answer to the rejection of strong out-of-band signals; the main factors involved embrace the type and siting of the aerial, the matching of the feeder, the characteristics, internal wiring of the receiver (particularly any resonances), and extension speaker leads. The RSGB has designed a filter (which has been examined by BREMA and the Home Office) and this is a possible solution to one of these aspects, although it requires modification to meet safety requirements if it is fitted internally. Even so, to include it as standard in receivers would mean an additional cost of at least £2M per annum to be paid by the purchasing public in the UK – and it would still not clear the interference if it enters the set other than via the down-lead.

With the increasing number of strong out-of-band signals to which sets at domestic sites are now being subjected, UK receiver manufacturers have, over the last few years, been incorporating a higher degree of immunity in their sets. However, it will be some years before all the older receivers are replaced and the overall problem will, therefore, be with us for some time to come. Unfortunately, the RSGB survey does not give information on the vintage of the affected receivers.

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TRANSIENT INTERMODULATION DISTORTION

During the past few months you have printed several articles by various contributors, as have other magazines, on the subject of a new distortion phenomenon which has been named transient intermodulation distortion (t.i.m.). The following properties have been claimed for this form of distortion:

1. It is transient in nature, and totally undetectable with steady state signals.
2. It may be prevented by ensuring that the pre-amplifier closed loop bandwidth is less than the power amplifier open loop bandwidth.
3. It is caused by blocking of an amplifier input stage due to overloading because of delay in the feedback signal.

Taking the second point first, Professor M. Otala in making this statement[1] gives the impression that t.i.m. is a bandwidth related phenomenon, whereas in fact t.i.m. is merely a new name for the distortion caused by slew rate limiting, and t.i.m. is generated when, and only when, the input signal slew rate is sufficient to cause the power amplifier to try to exceed its maximum slewing rate.

To illustrate the error of statement 2 above, it is possible to design a power amplifier with a slew rate of only 1 volt per microsecond at the output, but with an open loop bandwidth of 100kHz. According to Prof. Otala, t.i.m. will not be generated if the input signal bandwidth is less than 100kHz, but such an amplifier as described will slew at a frequency of the order of 5kHz at an output of 60 volts peak to peak, and t.i.m. will be generated at all higher frequencies if the input is maintained constant.

The claim that t.i.m. or slew rate limiting is undetectable with sine wave signals is not true, since a rapid increase in distortion may be very clearly seen with any amplifier using single pole second stage compensation as its output slew rate is approached.

T.i.m. is said to be far more likely with amplifiers using a large feedback factor than it is with amplifiers using a small feedback factor. However, since t.i.m. is produced whenever an amplifier input slew rate is exceeded (where input slew rate is defined as the maximum slew rate of the amplifier divided by its closed loop gain), it will be produced independently of the amount of feedback used. The only time when t.i.m. will be produced in practice with most reasonably high slew rate amplifiers is when they are feeding a capacitive load such as a Quad Electrostatic loudspeaker. The reason is as follows:

If an amplifier must provide 60 volts peak to peak at 20kHz into a load consisting of 2μF in parallel with 8 ohms, it must be capable of charging the capacitor at a maximum rate of $SR = 2\pi FV_{max} = 3.77\ V/\mu s$. Unfortunately, the maximum slew rate of a sine wave occurs as it goes through zero, i.e. when the resistive load is drawing no current. Thus the amplifier must supply sufficient current to charge 2μF at a rate of 3.8 volts/μs, i.e. it must supply 7.6 amps at zero output voltage.

Since this requirement is outside the safe operating area of the power transistors in most amplifiers, the protection circuits will normally operate, causing a delay in the feedback signal and the generation of t.i.m.

To the best of my knowledge no one has ever reported that t.i.m. is worse for Quad Electrostatic loudspeakers than it is for moving coil types, despite the fact that the effect is far more serious with heavy capacitive loads than it is with any other loads, and also despite the fact that t.i.m. is claimed to be clearly audible. It, therefore, seems apparent to me that people are hearing what they want to hear rather than what is really there.

The amplifier design[1] is claimed to be completely free from t.i.m. but if loaded by 2μF at its output, it will produce t.i.m. just like any other amplifier due to high frequency clipping by the protection networks in the output stage.

In conclusion, I would like to list the following points:

- T.i.m. is produced when and only when the input signal to an amplifier exceeds its input slew rate.
- Amplifiers with very heavy feedback are no more likely to produce t.i.m. than those with low values of feedback factor, although the internal overshoots may have higher amplitudes when slew rate limiting does occur.
- T.i.m. is far more likely when an amplifier is feeding an electrostatic loudspeaker than when it is feeding a moving coil unit.

M. Rigby,
Neve Electronic Laboratories Ltd,
Royston,
Hertfordshire.

Reference

1. "An audio amplifier for ultimate quality requirements" by Jan Lohstroh and Matti Otala. *IEEE Transactions on Audio and Electroacoustics*, volume AU-21, No. 6 December 1973.

Professor Otala replies:

Although Mr Rigby's letter is not addressed to me, I feel obliged to respond to it as my name is mentioned a few times.

Mr Rigby starts by stating that "... t.i.m. is generated when, and only when, the input signal slew rate is sufficient to cause the power amplifier to try to exceed its maximum slewing rate". This statement is false because
– exceeding the slewing rate corresponds to 100% momentary intermodulation distortion
– in most cases slew rate is not an abrupt limit, but the amplifier becomes highly non-linear already far below it. It is an established experimental fact that in commercial amplifiers t.i.m. is in many cases produced already at one tenth of the slew rate[1].

Mr Rigby continues by postulating an amplifier having a 1V/μs slew rate and a 100kHz open-loop bandwidth. This is intellectual dishonesty because either his 100kHz specification is the *small-signal* bandwidth, which is irrelevant in this context, or the amplifier feedback resistor is bypassed with a capacitor, in which case the amplifier does not slew at all but has a nice, clean signal rise without any nonlinearity. Consequently, in this case t.i.m. is not produced with any input signal.

Mr Rigby goes on to state that t.i.m. is detectable with the sine wave signals. It is unclear what he means by "sine wave signals". However, it is a rigidly established experimental fact that the standardized total harmonic distortion measurement method and the SMPTE intermodulation measurement method do not reveal t.i.m.[1, 2]. There are two reasons for this:
– the SMPTE-i.m. and the low-frequency t.h.d. input signals do not drive amplifiers near the onset of t.i.m., not to mention slew rate.
– if the t.h.d. measurement is attempted at a higher frequency, the harmonics will lie outside the passband of the amplifier and will suffer considerable attentuation.[1]

After this Mr Rigby claims that t.i.m. is independent of the feedback. The trivial error in this claim is the assumption that the slew rate would be a constant for a given amplifier. Let us take an operational amplifier as an example. If the feedback is increased, the stability considerations require that the frequency compensation must be changed. Increasing the compensation capacitor proportionally to the feedback decreases the open-loop upper cut-off frequency. The slew rate o the amplifier will then be inversely proportional to the feedback factor, i.e. the higher the feedback, the smaller the slew rate. This is a simple basic relationship which leads on to the fact that t.i.m., if it is generated, is directly proportional to the feedback factor, as has been shown both theoretically[3] and experimentally[5].

There are a number of other claims that may require a short comment.
– T.i.m. may be prevented by ensuring that the pre-amplifier bandwidth is smaller than the power amplifier open-loop bandwidth[3,4]. However, this is not the only possible way and reactive feedback with pole cancelling is probably one of the best alternatives[6].
– Mr Rigby's claim that a certain amplifier[7] produces t.i.m. due to high-frequency clipping in the output stage protection networks is inconceivable, because that amplifier does not incorporate any protection networks.
– measurements showing that certain amplifiers produce gross t.i.m. when used with capacitive loads were reported by Scott Kent at the Boston Audio Society Distortion Symposium, Boston, Mass., 1976.

In brief, it has been shown that Mr Rigby's first two conclusions are false, and that his third conclusion is correct, although on other grounds than those he discusses.

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3. Otala, M., Leinonen, E., The theory of transient intermodulation distortion. *Monitor-Proc. IREE*, vol. 37 (1976), no. 5, pp. 53-59. To be republished in *IEEE Transactions on Acoustics, Speech and Signal Processing*, February 1977.
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NEW CONCEPT FOR AMPLIFIER SPECIFICATIONS

There has been much correspondence recently about load specifications of audio amplifiers. I would like to suggest that it is possible to look at this problem from a wider point of view which might give more insight into the ways of specifying performance.

I do not think it is too outrageous to suggest that the specifications of a piece of audio equipment should define the way in which it performs audibly, since it is surely the character of the sound reproduced which is of greatest interest.

I think it would be helpful to extend our understanding of audio amplifiers by introducing a concept which I suggest should be called "loss of information" (l.o.i.). This concept will allow us to differentiate between the various mechanisms that degrade the audio signal. For example, harmonic and intermodulation distortion do not result in loss of information, while slew-rate limiting, clipping and protection activation do result in l.o.i.

Let us consider why this idea has not come to light before. When valves were in common use the parameters on which effort was expended were those of harmonic distortion and bandwidth. However, valve hi-fi amplifiers were usually designed so that slew-rate limiting and t.i.d. did not occur. This was due in part to the limited bandwidth and in part to the high frequency characteristics of valves; also protection was not required, so it is unlikely that a well-designed valve amplifier has any l.o.i. mechanisms. When transistor amplifiers first appeared, commercial pressures, not unnaturally, led designers to seek lower t.h.ds and wider bandwidths, apparently without any appreciation of the possible side effects. I would like to suggest that in fact it is the loss of information mechanisms that account for most of the variations in sound quality between one audio amplifier and another, and more particularly between a valve amplifier and a transistor amplifier.

It should be noted that crossover distortion is made up of high order odd harmonics which in themselves are not audible even at quite high levels. Crossover non-linearities, however, generally result in l.o.i. and it is this that makes the crossover distortion audibly objectionable.

A further aspect of l.o.i. occurs when the amplifier suffers from any form of latch-up – a short initial loss of information will be followed by a prolonged loss while the amplifier recovers. This will make the sound quality even less acceptable. To improve the quality of the sound it is necessary not only to try to eliminate the causes of l.o.i. but also to ensure that where l.o.i. does occur (e.g. clipping) it is limited to the shortest possible time.

It can be seen that the question of load specification is more complex than it would appear at first sight. If the amplifier's protection is activated by any combination of musical signal and loudspeaker load, there will be a loss of information and a consequent deterioration in the sound quality. To avoid this source of deterioration implies that the amplifier's dynamic output impedance should remain substantially constant. This is somewhat at variance with Mr Peter Walker's proposals as stated in his letter in the December, 1975 issue of *Wireless World*.

J. Vereker,
Naim Audio Ltd,
Salisbury,
Wilts.

METAL DETECTORS AND ARCHAEOLOGY

I am writing as a consequence of the article published in your April issue "Sensitive metal detector" by D. E. O'N. Waddington. I beg to call into question the propriety and wisdom of printing such an article, for although you warn your readers about not using such a detector on known archaeological sites, you must realize that such a warning is useless for anyone who is determined to use a metal detector for personal gain, with no regard for other considerations.

You might have just as easily printed details for the construction of a shotgun, and then reminded your readers not to point it at anyone.

In the past treasure hunters have maintained that their equipment was not sensitive enough to detect coins etc more than a few inches below the surface, and so could not destroy archaeological stratigraphy; if the claims which are made in your advertisements are true, you have presented this group with the opportunity to probe to the very earliest levels, to destroy valuable information, which is the heritage of every-