

The present invention relates to a class AB amplifier and to the distortion corrector which is combined with it with the object of obtaining linear amplification and, in particular, linear power amplification for television signals.

It is known that, for example, the amplification of a modulated wave by an asymmetrical spectrum in the picture channel and, a fortiori, joint amplification of sound and picture in the same channel, require linear amplifiers. It therefore seems necessary to use class A or class B amplifiers, but considerations of output and feasibility prevent linear power amplification from being carried out in this way. This amplification is therefore carried out in class AB.

Linear power amplification, as practised up to now, displays poor linearity for the weak signals; this is due, as will be shown below, to a well-established precedent.

It is the object of the present invention to allow good-quality class AB linear amplification; this is obtained by going against the above-mentioned precedent.

According to the invention a class AB amplifier and the distortion corrector thereof, the corrector comprising a corrector of troughs, are characterised in that the zero signal current of the amplifier is selected such that the characteristic $V_s = f(V_e)$ of the amplifier (where V_e and V_s are the input and output voltages of the amplifier respectively) has a derivative with steady variation for low levels, and in that the characteristic $V_s' = f(V_e')$ of the trough corrector (where V_e' and V_s' are the input and output voltages of the trough corrector respectively) has a concavity directed towards increasing values, at least in absolute value, of V_s' .

Patent US-A-4 152 665 concerns a device for improving the linearity of FM receiving circuits. However, this supposes that the type of distortions to be corrected are already known.

The present invention will be understood better, and further characteristics will be apparent, with the aid of the description below and the figures relating thereto,

which show:

- figure 1, a first graph relating to class AB amplification,
- figure 2, the schematic diagram of a class AB amplifier,
- figures 3 to 5, graphs relating to the amplifier of figure 2,
- figure 6, a transmission line with class AB amplification,
- figures 7 and 9, circuits for the correction of class AB amplifiers,
- figures 8 and 10, graphs relating to the circuits according to figures 7 and 9 respectively.

The study below is made within the scope of simultaneous amplification of sound and picture television signals transmitted on the same channel; but the conclusions which it reaches are valid whatever the type of signal to be amplified linearly in class AB.

Figure 1 shows a characteristic $I_c = f(V_b)$ of an amplifier in which I_c refers to the collector current of a transistor and V_b the base-emitter voltage of this transistor. In this figure is indicated the zero signal current I_0 , which is a function of a bias voltage V_{bo} , characteristic of class AB operation of the amplifier in question; during operation, the vertical of abscissae V_{bo} forms the axis of symmetry of the signal to be amplified, of which the envelope S is shown in figure 1.

Figure 2 shows the schematic diagram of a class AB amplifier. This amplifier comprises an NPN power transistor T mounted as a common emitter, with an impedance matching circuit 21 between its base and the amplifier input and another impedance matching circuit mounted between its collector and the amplifier output. The bias of the transistor base is provided via an assembly consisting of an inductance L1, a potentiometer R and two resistances R1, R2; the inductance L1 connects the base of the transistor to the cursor of the potentiometer; the ends of the potentiometer are connected to a d.c. voltage source +V by the resistance R1 and to earth by the resistance R2, respectively. The bias of the transistor collector is

provided via an inductance L2 which connects this collector to the voltage +V; the transistor emitter for its part is connected directly to earth.

The potentiometer R makes it possible to adjust the zero signal current of the transistor in the absence of a signal at the amplifier input.

Figure 3 is a graph which shows the variation in output voltage V_s of the assembly according to figure 2 as a function of the input voltage V_e , the transistor being biased by a weak zero signal current I_0 (see figure 1).

In order to regulate the amplifier according to figure 2, adjustment of the potentiometer R (figure 2) seems the most obvious and easiest solution. Generally there is an optimum position of the potentiometer, corresponding to a precise bias current value, at which there is obtained a minimum value of intermodulation products arising from interference between the sound signal and the picture signals, and a minimum value of regeneration of the attenuated band. But these minimum values are not satisfactory, and observation of the picture signal causes one to suspect streaking at low levels of the signal.

In the study, begun with the aid of figure 3, of behaviour of the transistor, reading of the curve in the vicinity of zero requires such a change of scale on the measuring instruments, that it is neglected. By association of ideas with figure 1, the curve Cp of figure 3 is completed towards the low levels by a curvature similar to that of the curve C (figure 1) and hence with a concavity directed towards increasing values of V_s ; it is the curve C0 in broken lines which will be discussed on the occasion of the description of figure 4. This therefore leads, in order to try to obtain linear amplification, to introducing a corrector element of which the variation in output voltage V_s' relative to its input voltage V_e' has the appearance of curve C_a , in broken lines, of figure 10. As proof, a document of the company RCA entitled "The RCA TTG-10 (III) and TTG-12H internally diplexed television transmitters", presented within the framework of the N.A.B. (National Association of Broadcasters) exhibition of 1983,

shows on page 6 on the one hand a correction curve which, for low levels, is of the type of the above-mentioned curve C_a and, on the other hand, of course, a response curve of the amplifier to be corrected at low levels which is the one indicated above, namely: concavity directed towards increasing values of V_s . But experience shows that both for class AB amplifiers equipped with transistors and for those equipped with tubes, this is not so: the concavity is directed towards increasing values of V_e and at the very most, according to the selected operating point, the curve may, after the first few values, exhibit a turning point and, only after this, exhibit a concavity directed towards increasing values of V_s at least in so far as V_e and V_s are positive voltages. More generally, all that has been or will be said in this text in relation to curvatures in comparison with the values entered by the axes of coordinates, is valid even if the values in question are negative, on condition of taking only the absolute values into account.

Figure 4 shows a reading of characteristics $V_s = f(V_e)$ for a class AB amplifier as indicated in figure 2. Three curves C1, C2, C3 have been plotted respectively for three operating points 1, 2, 3 indicated on the curve of figure 5 which gives the variations in the zero signal current I_c of the collector of the transistor T as a function of the base bias V_b . Moreover, in figure 4 is shown in broken lines the curve C0 of behaviour of the amplifier, as it was supposed to be for low levels.

In figure 4 the scale is increased in the vicinity of zero on the two axes of coordinates, in order to show the appearance of the curves C0, C1, C2, C3 for the low levels better. For the high levels the curves all have the appearance already observed in figure 3. For low levels the slope of the curves $V_s = f(V_e)$ of figure 4 in the vicinity of zero is proportional to the slope of the tangent, not shown, to the curve of figure 5 at the selected operating point: point 1 for C1, 2 for C2 and 3 for C3.

The curves C1 to C3 all exhibit in the vicinity of

zero a curvature directed towards increasing values of V_e but, still at the low levels, the curves C2 and C3 each have a turning point. These turning points make it difficult to produce a corrector having the inverse characteristic; it is therefore preferable to select a response of the type of curve C1 to facilitate correction, that is, to select a response $V_g = f(V_e)$ of which the derivative has a steady variation. The zero signal current of the class AB transistor (or tube) must therefore be enough to avoid a turning point on the curve $V_g = f(V_e)$, and it is not because the intermodulation products will be greater that they will be more difficult to correct; on the contrary, the attitude consisting of trying to reduce them by bias would greatly complicate correction.

The precedent which consisted of trying to correct an amplifier response of the type of curve C0 and not of the type of curves C1 to C3 (figure 4) explains that the results obtained were imperfect (in the event that in reality the response was of the type of curves C2 and C3) or even bad (response of type C1).

The corrector intended to correct a class AB amplifier operating at radio frequency is practically always inserted at intermediate frequency in the transmission line comprising the amplifier; it is enough for the transmission quadrupole between the corrector and the amplifier to be corrected to have a sufficient passband. This applies not only to the known correctors, but also to the correctors according to the present invention.

Figure 6 is the schematic diagram of a transmission line with frequency changing, in which an amplifier and the distortion corrector thereof are combined in order to produce linear amplification of the input signal. The signal to be transmitted is applied, via a distortion corrector 1, to the signal input of a frequency changer 2 of which the frequency changing signal is at the frequency F; the signal at radio frequency obtained at the output of the frequency changer is applied to the input of a class AB amplifier 3. This diagram corresponds to linear class AB amplification both according to the prior art and according

to the present invention, and as will be apparent below, the technological modifications necessary to carry out the invention from the prior art are simple.

A distortion corrector like the corrector 1 of figure 6 is formed by a trough corrector for the correction of low levels and, optionally if the amplifier operates in the vicinity of saturation, a peak corrector placed in series with the trough corrector.

A peak corrector used in one embodiment according to the invention is shown in figure 7. It is composed of four circuits in parallel, one 10 of which is linear and the other three of which are correction circuits operating in class C. These four circuits, which have variable gain and bias, make it possible to adjust the thresholds and efficiency of correction. The resulting characteristic "output signal V_{s1} relative to the input signal V_{e1} " is shown in figure 8; this is a broken line C_c which is an approximation of the model curve to be produced in order to make the response of the transmission line according to figure 6 linear, at medium and strong levels of the signals. Equivalent peak correctors are located in the known distortion correctors used to obtain linear amplification whatever the class of operation.

A trough corrector used in one embodiment according to the invention is shown in figure 9; its response curve $V_s' = f(V_e')$ is represented by the curve C_i of figure 10; this is substantially the inverse curve of the curve C_a shown in broken lines in figure 10 which, according to precedent, used to be used to try to make the response at low levels of the transmission line according to figure 6 linear. The trough corrector according to figure 9 comprises three branches connected in parallel with, in the first one, a correction circuit 14 consisting of a symmetrical linear amplifier with peak clipping thresholds, in the second one, a correction circuit 15 consisting of a symmetrical linear amplifier with peak clipping thresholds of which the thresholds are different to those of circuit 14, and, in the third one, a linear circuit 16 in series with a π phase shifter 17.

The curve C_a of figure 10, that is, the correction curve according to precedent, would be obtained by summation of the output signals of the three circuits 14 to 16, without the phase shift of π ; thus the diagram of figure 9 corresponds, by replacing the phase shifter 17 by a short circuit, to a trough corrector according to precedent. In order to obtain the curve C_i , which is the inverse of the curve C_a , it is no longer necessary to add the output signals of the three circuits 14 to 16, but to perform subtraction between the output signal of the linear channel, that is, of circuit 16, and the output signals of the correction circuits 14 and 15. For this subtraction it is enough to perform a phase shift of π ; this is the role of the phase shifter 17 of figure 9, which is shown by a rectangle with a contour in broken lines. This representation in broken lines of the phase shifter 17 has a dual purpose: on the one hand to show the difference between a trough corrector according to precedent and a trough corrector in which the precedent has been overcome, and on the other hand to indicate that the subtraction concerned is not necessarily performed by the addition of this phase shifter; in order to obtain this subtraction from the trough corrector according to precedent, it is in fact also possible either to eliminate an inverter stage in the correction circuit 16 if it has one, or to add a π phase shifter in series with the correction circuits 14 and 15, or to eliminate an inverter stage in each of the correction circuits 14 and 15 if they each have one.

The present invention is not confined to the example described, and so it is that the peak correctors can be manufactured by any method already employed in distortion correctors according to precedent; the same applies, with the exception of inversion of the curve (see figure 10), to the trough correctors. The distortion corrector for its part may be arranged not only at intermediate frequency, as in the case of figure 6, but also at radio frequency, before or after the class AB amplifier.



Claims

1. Class AB amplifier and distortion corrector thereof, the corrector (1) comprising a corrector of troughs (14-17), characterised in that the zero signal current (I_0) of the amplifier (3) is selected such that the characteristic $V_s = f(V_e)$ of the amplifier (where V_e and V_s are the input and output voltages of the amplifier respectively) has a derivative with steady variation for low levels, and in that the characteristic $V_s' = f(V_e')$ of the trough corrector (where V_e' and V_s' are the input and output voltages of the trough corrector respectively) has a concavity directed towards increasing values, at least in absolute value, of V_s' .

2. Amplifier and distortion corrector thereof according to claim 1, in which the amplifier (3) operates at radio frequency, characterised in that the distortion corrector (1) operates at intermediate frequency.