Groupe 11,53.

1 Annexe documentaire

Dans cette annexe nous présentons la démarche utilisée lors de la recherche documentaire incluant : le choix de thème, les mots clés et la méthode de recherche et quelques traces de nos recherches.

Une bibliographies complète de tout notre rapport est également présente en fin de section.

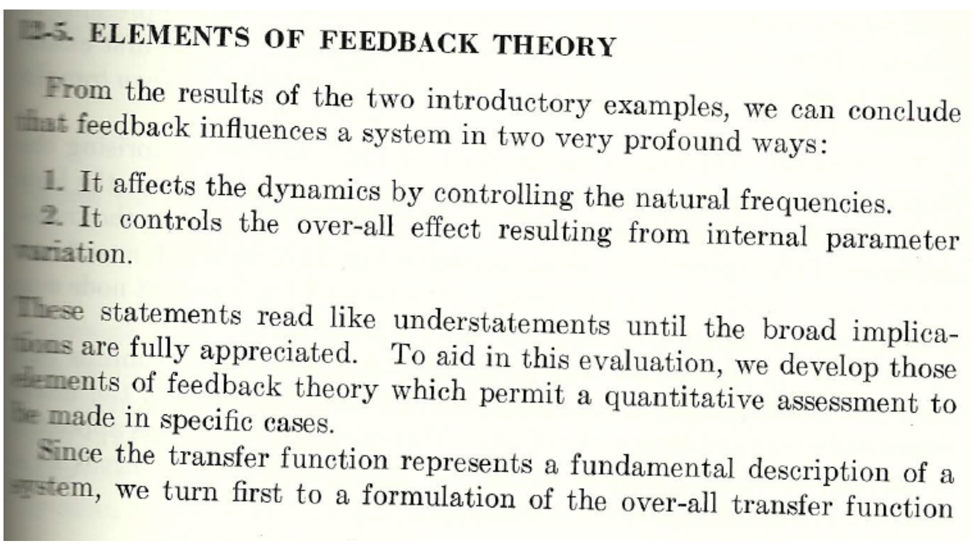
1.1 La contre-réaction ou réaction négative

Choix du thème En analysant le circuit qui compose notre haut-parleur, nous avons remarqué la présence de boucle reliant la sortie des amplificteurs à leur bornes négatives. Nous nous sommes alors pourquoi ces boucles étaient là, et quels étaient leurs rôles dans le cadre de notre haut-parleur. Après quelques recherches sur internet, nous avons pu identifier ces boucles comme étant des boucles de contre-réaction ; nous avons alors pu commencer notre recherche.

Mots clés et méthode de recherche Comme suggeré lors de la séance d'information sur la recherche bibliographique, nous avons appliqué la méthode de l'entonnoir. Comme les boucles de contre-réaction sont directement liées aux amplificateurs, nous avons commencé nos recherches avec les termes plutôt généraux : *amplificateurs* et *amplifiers*. Nous nous avons ensuite associé à ces mots clés les termes plus précis : *contre-réaction* et *negative feedback*.

Les différents ouvrages et documents que nous avons utilisés sont listés dans la bibliographie.

Quelques traces de notre recherche Voici quelques traces de notre recherches (Figures 1 et 2), issues du livre *Principle of electronic instrumentations*, par LYNCH et TRUXAL aux éditions MCGRAW-HILL.



12-5. ELEMENTS OF FEEDBACK THEORY

From the results of the two introductory examples, we can conclude that feedback influences a system in two very profound ways:

1. It affects the dynamics by controlling the natural frequencies.
2. It controls the over-all effect resulting from internal parameter variation.

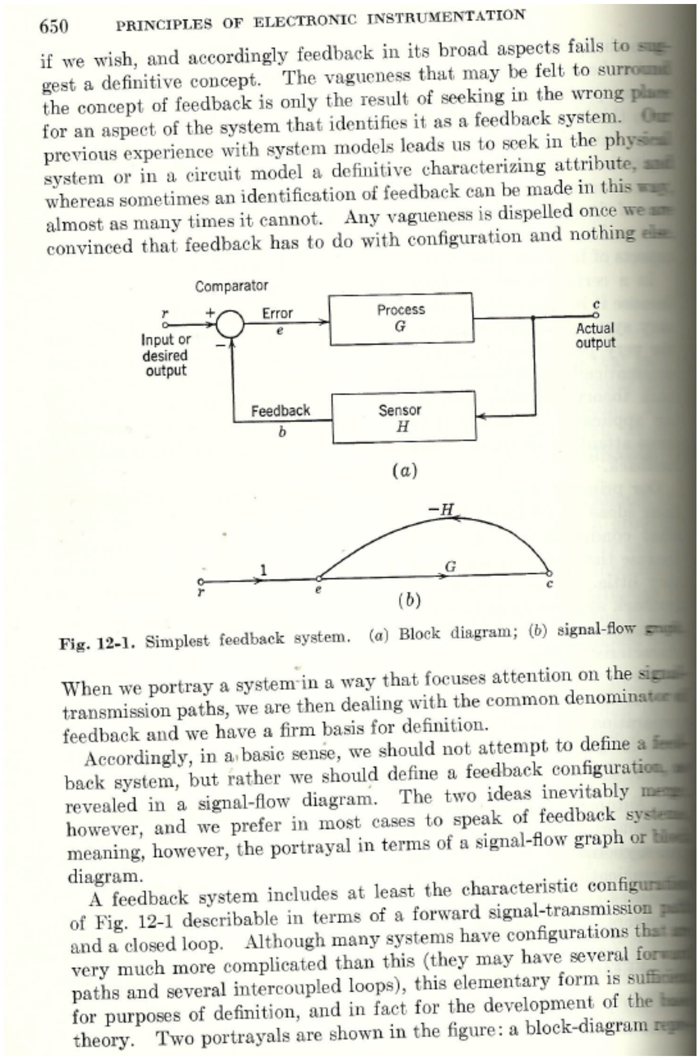
These statements read like understatements until the broad implications are fully appreciated. To aid in this evaluation, we develop those elements of feedback theory which permit a quantitative assessment to be made in specific cases.

Since the transfer function represents a fundamental description of a system, we turn first to a formulation of the over-all transfer function

FIGURE 1 – Page 670

1.2 La distorsion harmonique

Choix du thème Le choix du thème n'a pas été chose aisée. Nous avons commencé par établir un brainstorming afin de réunir le plus d'idées possibles. Cependant, les thèmes proposés nous semblaient trop généraux que pour faire un vrai travail en profondeur tout en restant concis. Quelqu'un a finalement proposé la distorsion harmonique ; un terme visible sur les emballages de haut-parleurs. Nous avions également repéré ce terme dans la datasheet de l'amplificateur audio reçu pour le projet : une valeur de 0,2% était renseignée



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if we wish, and accordingly feedback in its broad aspects fails to sug-gest a definitive concept. The vagueness that may be felt to surround the concept of feedback is only the result of seeking in the wrong place for an aspect of the system that identifies it as a feedback system. Our previous experience with system models leads us to seek in the physical system or in a circuit model a definitive characterizing attribute, and whereas sometimes an identification of feedback can be made in this way, almost as many times it cannot. Any vagueness is dispelled once we are convinced that feedback has to do with configuration and nothing else.

Fig. 12-1. Simplest feedback system. (a) Block diagram; (b) signal-flow graph.

When we portray a system in a way that focuses attention on the signal-transmission paths, we are then dealing with the common denominator of feedback and we have a firm basis for definition.

Accordingly, in a basic sense, we should not attempt to define a feed-back system, but rather we should define a feedback configuration, as revealed in a signal-flow diagram. The two ideas inevitably merge, however, and we prefer in most cases to speak of feedback systems, meaning, however, the portrayal in terms of a signal-flow graph or block diagram.

A feedback system includes at least the characteristic configuration of Fig. 12-1 describable in terms of a forward signal-transmission path and a closed loop. Although many systems have configurations that are very much more complicated than this (they may have several forward paths and several intercoupled loops), this elementary form is sufficient for purposes of definition, and in fact for the development of the basic theory. Two portrayals are shown in the figure: a block-diagram rep-

FIGURE 2 – Page 650

pour le THD (taux de distorsion harmonique). Curieux d'en apprendre plus sur ce terme presque méconnu, nous avons décidé de débuter notre travail de recherche là-dessus.

Mots clés et méthode de recherche Etant donné que nous ne connaissions vraiment que très peu sur ce sujet et que nous devions le comprendre en profondeur, nous avons commencé par le terme général de "distorsion". Une première recherche sur internet a permis de fixer les idées à propos de ce terme, et nous avons ensuite pu établir une liste de mot-clefs pour entamer réellement la recherche sur la distorsion harmonique. Nous avons appliqué la "technique de l'entonnoir", et nous avons finalement réuni assez d'informations que pour écrire ce rapport. Notons tout de même que c'est indiscutablement en anglais que nous avons trouvé le plus d'informations. Nous avons gardé une trace de toutes les sources que nous avons consultées, et cela a rendu l'écriture de la bibliographie nettement plus facile.

Quelques traces de notre recherches

Distortion power is not identical to real power and its value for sinusoidal conditions is zero.

Reactive power can be represented by,

$$Q = \sum_{n=1}^{\infty} V_n \cdot I_n \sin(\theta_n - \delta_n) \tag{6}$$

Power factor concept is used to determine how a current from AC power system is efficiently utilized by a load. In both sinusoidal and non-sinusoidal cases, power factor can be expressed as follows,

$$PF = \frac{P}{S} \tag{7}$$

2.2. Total Harmonic Distortion (THD)

Total harmonic distortion, THD, most-widely used index in related standards, is used to determine the deviation of the periodic waveform containing harmonics from the pure sinusoidal waveform. The total harmonic distortion of voltage and current waveform respectively can be expressed as following,

$$THD_V = \frac{\sqrt{\sum_{n=2}^{\infty} V_n^2}}{V_1} \tag{8}$$

$$THD_I = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_1} \tag{9}$$

As seen from Eq. (7) and (8), total harmonic distortion is the ratio between rms values of harmonic components and rms value of fundamental component, and, is usually represented in percentage. THD value is equal to zero in a pure sinusoidal waveform.

2.3. Total Demand Distortion (TDD)

Total demand distortion, TDD, is related to particular load and defined as total harmonic current distortion,

$$TDD = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_L} \tag{10}$$

FIGURE 3 – Celal Kocatepe, Recep Yumurtacı, Oktay Arıkan, Mustafa Baysal, Bedri Kekezoğlu, Altuğ Bozkurt and C. Fadıl KumruHarmonic, *Effects Of Power System Loads : An experimental Study*, edition Intech.

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high frequency content then one can overcome that distortion with a high-boost filter. It may not always be easy to compensate for linear distortion if the processing system is very complicated, but in principle one can always do it. All it takes is a sufficiently specialized filter at the receiving end.

17.2.3 Nonlinear Distortion

Although linear distortion may be rather benign, nonlinear distortion is not. It is the most serious kind of distortion because it can be highly unpleasant and there is no simple way to get rid of it. In general, nonlinear distortion cannot be removed by filtering.

Nonlinear distortion by a device or process results in the addition of extra frequencies to the output of the device or process. That is the most significant difference between nonlinear distortion and linear distortion. For instance, if the input to a device has spectral power at frequencies of 100, 223 and 736 Hz then the output of a linear device will have power at only those three frequencies. The amplitudes may be boosted or attenuated differently, the phases may be scrambled, but there won't be any new frequencies. With nonlinear distortion there will be at least a few new frequencies added, and normally a lot of new frequencies will be added.

The Origins of Distortion Imagine a clock pendulum that is slowly oscillating back and forth,smoothly and unobstructed. Clearly the motion is periodic. It is nearly sinusoidal, but not exactly sinusoidal, and a complete description of the motion would include a few harmonics. Now imagine that someone puts up a barrier so that just before the pendulum reaches its maximum displacement to the right it runs into the barrier—bonk! The pendulum motion continues, it even continues to be periodic, but the pattern of motion is obviously changed by the obstruction—the pattern has been distorted. One might say that the pattern has been "clipped" in the sense that the barrier prevents the pendulum from reaching the full extent of vibration.

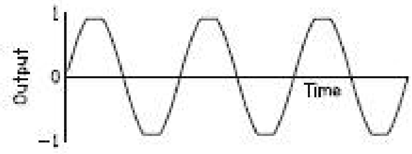
Distortion occurs in a loudspeaker driver if you use a finger to prevent the loudspeaker cone from reaching the maximum displacement that the audio signal wants the cone to make. This kind of distortion occurs in a driver, even without interference from the outside, because physical limits in the cone mounting prevent the cone from making very large displacements. If the audio signal sent to a loudspeaker is very large, the signal will try to cause the cone to make extreme displacements and gross nonlinear distortion will occur.

Distortion occurs in audio devices that are purely electronic when the limits of the electronic circuitry are exceeded by a signal that is amplified too much. The usual way to study nonlinear distortion by a process or device is to use one or two sine waves as inputs—thus only one or two frequencies. If there are more, the situation becomes very complicated.

FIGURE 4 – Principles of musical acoustics, William M., Hartmann., Undergraduate Lecture Notes, Springer, New York.

17.2 Distortion 183

Fig. 17.2 A sine tone suffering symmetrical clipping. Only odd-numbered harmonics (3, 5, 7, ...) are produced by this distortion



Harmonic Distortion If a sine tone is put into a system that clips off the top there is a change in the waveshape. The tone remains periodic because every cycle of the sine tone has its top clipped off in the same way. Therefore the period is not changed by this clipping, but the signal is no longer a sine tone; it is now a complex tone. The complex tone has a fundamental frequency equal to the frequency of the original sine tone, and now it has harmonics. This is called harmonic distortion. This kind of clipping can be expected to generate harmonics of all orders, both even and odd. The second harmonic or the third will normally be the strongest.

If the nonlinear system clips off the top and the bottom of the sine tone symmetrically, as in Fig. 17.2, then the output includes only odd-numbered harmonics as distortion products.

Intermodulation Distortion If you put two sine tones (frequencies f_1 and f_2) into a nonlinear system, you expect there to be harmonic distortion products, with frequencies $2f_1$ and $2f_2$, also $3f_1$ and $3f_2$, and so on. However, there is more. There are also summation tones and difference tones generated by the nonlinearity. Summation tones occur at frequencies generically given by the formula $mf_2 + nf_1$, where m and n are integers. Frequencies $f_2 + f_1$ and $2f_2 + 3f_1$ are examples.

Difference tones occur at frequencies generically given by the formula $mf_2 - nf_1$, where m and n are integers. The most important difference tones are usually the following three: $f_2 - f_1$, $2f_1 - f_2$, and $3f_1 - 2f_2$. In using these formulas, we consider f_2 to be the larger frequency and f_1 to be the smaller. Normally, then, the formulas will lead to positive frequencies for the distortion tones. However, if one of the numbers you calculate turns out to be negative, you can find a legitimate distortion frequency simply by reversing the sign and making it positive.

Of all these distortion products, the difference tones are the worst. They are easy to hear and are the among the most objectionable features of poor audio. As an example, if two sine tones, with frequencies of 2,000 and 2,300 Hz are put into a nonlinear device, the difference tones $f_2 - f_1$, $2f_1 - f_2$, and $3f_1 - 2f_2$ become, 300 Hz, 1,700 Hz, and 1,400 Hz, as shown in Fig. 17.3.

Distortion in the Cochlea The neural transduction that takes place in the cochlea is a highly nonlinear operation. Therefore you expect that the cochlea generates distortion products. For instance, it should generate harmonic distortion. However, the curious nature of wave propagation in the cochlea saves us listeners from that distortion. You will recall that in the cochlea, sounds travel from the high-frequency end (base) toward the low-frequency end (apex). Suppose that there is a 200 Hz tone that is being transduced by the cochlea. Because 200 Hz is a rather

FIGURE 5 – Principles of musical acoustics, William M., Hartmann., Undergraduate Lecture Notes, Springer, New York.

Références

[1] AMT. Alimentation dc : Topward 3303 ds, Janvier 2007.

[2] Pierre Auger. Encyclopédie internationale des sciences et des techniques, 1969.

[3] H. S. Black. Stabilized feedback amplifiers, 1934.

[4] H. S. Black. Inventing the negative feedback amplifier, 1977.

[5] J. Chevassus, T. Nkaoua, J.M. Villafranca, and N. Benoist. Traitement acoustique : principes de base.

[6] Universal Electric Corporation. *Charges non-linéaires et harmoniques*. Starline, Mars 2014.

[7] Marc Correvon. Systèmes électroniques.

[8] C. Louis Cuccia. *Harmonics, sidebands, and transients in communication engineering : as studies by the Fourier and Laplace analysis*. McGraw-Hill, 1952.

[9] Marcel J. Van der Houst, Wouter A Serdijn, and André C. Linnenbank. *EMI-Resilient Apmlifier Circuits*. Springer, 2013.

[10] S. Dusausay. Effets de la contre réaction sur les amplificateurs.

[11] Guy Galus. Paramètres de thiele-small.

[12] William M. Hartmann. *Principles of Musical Acoustics*. Springer, 2013.

[13] Texas Instruments. Lm380 2.5w audio power amplifier.

[14] Ronald G. Jawernycky, Michael Z. Lowenstein, Gerald L. Park, and Myron Zucker. Apparatus for measuring harmonic distortion in a conductor, and methods of constructing and utilizing same, 1989.

[15] J. Jouhaneau. *Enceintes aux basses frequences*. Ed. Techniques Ingénieur, 2014.

[16] C. Kocatepe, R. Yumurtaci, O. Arikan, M. Baysal, B. Kekezoglu, A. Bozkurt, and C. F. Kumru. *Harmonic Effects of Power System Loads : An Experimental Study*. Intech, Mai 2014.

[17] Larousse. Le lexis - le dictionnaire érudit de la langue française, 2014.

[18] Tout le haut parleur. Davis acoustics.

[19] Tout le haut parleur. La charge pour le haut-parleur.

[20] Donald J. Lucas and Edwin W. Rowand Jr. Method and apparatus for harmonic distortion correction, 1994.

[21] Lynch and Truxal. *Principles of Electronic Instrumentration*. McGraw-Hill, 1962.

[22] Multi-Contact. Technical data sheet - cable flexi-e 0.10.

[23] Encyclopaedia Universalis SA. Encyclopaedia universalis, 1990.

[24] R Sporken and J.L. Longueville. Physique des télétransmissions, 2007.

[25] Frederick Emmons Terman. *Radio engineering*. McGraw-Hill, 1947.

[26] Martin Weik. *Computer Science and Communication Dictionary*. Kluwer Academic Publishers, 2001.

[27] Wikipédia. Perméabilite magnétique, 2013.

[28] Hugh D. Young and Roger A. Freedman. *Sears and Zemansky's University Physics with Modern Physics Technology Update*. Pearson Education, 13th edition, 2013.