High fidelity equipment is becoming more complex and versatile. At the same time, modern research techniques are revealing more information about the intricate relationships between human hearing mechanisms, acoustic environment and sound reproducing apparatus. Each new revelation inevitably leads to debate and conjecture by the public and within the hi-fi trade. Very often, fresh information is presented with undue bias or without regard to all the factors involved. In such cases the public are frequently misled about the true benefits of new trends. The present craze for dc coupled amplifiers is a case in point.

In an attempt to assist informed technical debate on new developments, "KEFTOPICS" will report on discoveries and new techniques from a loudspeaker maker's standpoint. It will also deal with the results of investigations undertaken by KEF using its own computer research facilities.

If you have any comments on the content, format or usefulness of KEF Topics, kindly address your remarks to The Editor, KEF Topics, Tovil, Maidstone, Kent, ME15 6QP, England.
Production and Quality Control

Part 1 — Dividing Networks

Quality control is essential for two specific reasons: it ensures the reliability of the product during its lifetime, and guarantees consistency of performance throughout the entire production.

A vital part of the success of KEF has always been the detailed attention given to quality control and quality assurance. This is as essential for dividing networks as any other component in a loudspeaker system.

Dividing networks consist of inductors and capacitors arranged in a specific circuit configuration and, in the case of KEF, mounted on a printed circuit board.

Small variations of tolerance in the basic components of a dividing network can combine to seriously upset the tonal balance of a loudspeaker. Careful control of component values is therefore essential.

Selecting the Components

Before crossover components are issued to the production department each one is subjected to a quality control procedure.

All capacitors are measured individually for capacitance value and loss factor (Q). They are sorted into groups of ± 2.5% tolerances before being repacked and labelled ready for use.

The other important component in the network is the inductor. KEF manufacture their own, maintaining strict control over core characteristics, wire gauge and winding accuracy.

Printed Circuit Boards

KEF pioneered the use of printed circuit boards in the early 60s, not only to obviate wiring faults, but to ensure precise geometrical layout of the components. Cross coupling can occur between different filter sections due to mutual inductance. It is therefore vital to locate the inductors precisely with respect to each other and to avoid subsequent movement by strong nylon bindings.

Final Test

The final test involves a listening comparison between a laboratory maintained reference crossover unit and the production item. Since the ear will be the arbiter of quality, it represents an extremely sensitive check for any variations in crossover performance due to variations in component values or production faults.

100% inspection of components, coupled with a hand assembly operation, ensures long and trouble free life.

Loudspeaker specification

Part 1 — Impedance

The impedance of an electrical circuit is an expression of its resistance to conduct electric current. The higher the impedance the higher the voltage required to make a given current flow through the circuit. Mathematically it is expressed as the ratio of voltage over current, thus:

$$Z = \frac{V}{I}$$

Where $V$ is the applied voltage and $I$ is the current which flows through an impedance $Z$.

In alternating current circuits where voltage and current are often out of phase, the impedance has to be defined in terms of both magnitude (modulus) and phase angle.

$$Z = |Z| \angle \theta$$

Where $|Z|$ is the modulus of impedance and $\theta$ is the phase angle between voltage and current flowing in the circuit.

Interpretation

The impedance of a loudspeaker system varies with frequency. It is customary to show the impedance in technical specifications in the form of “an impedance curve”. A typical example is shown in figure 1 and for completeness both the magnitude and phase angle are included, although in most technical data sheets the phase characteristic is usually omitted.

Figure 1
Graph showing the $|Z|$ modulus of impedance (lower curve) and $\theta$ the phase angle (upper curve) for a typical two-way loudspeaker system. The dotted line shows the nominal impedance of the loudspeaker and the arrow, the frequency at which the tone burst of figure 2 was taken.
Matching Loudspeakers and Amplifiers

Various factors can affect the overall sound quality produced by particular loudspeaker/amplifier combinations. Some are obvious but others, although equally important, are more subtle and are frequently overlooked.

Compatibility
Most transistorized power amplifiers are designed to give their maximum output, with minimum distortion, into a specified load impedance usually 4, 8, or 16 ohms and this should correspond with the nominal impedance of the loudspeaker. In an ideal world where either all loudspeaker impedances were purely resistive or amplifiers could deliver their rated output into a specified load impedance of any phase angle, this simple matching procedure would suffice.

Unfortunately it is common practice, with modern wide bandwidth amplifiers, to fit voltage-dependant current limiting circuits in order to protect the fast and relatively fragile output transistors. The circuits detect the peak voltage across and the current through the output transistors and are arranged to operate at progressively lower currents as the voltage across the output transistors increases. For a nearly resistive load (phase angle close to 0°) the output device delivers maximum current when the voltage across it is a minimum, but when the load is highly reactive (phase angle close to 90°) the condition of maximum current corresponds with a high voltage across the output device. As a result the protection circuit comes into operation at much lower levels when the load impedance is reactive. This condition can occur with a loudspeaker when, although the modulus of impedance appears to be satisfactory and close to the nominal value, the phase angle is quite large.

The basic information needed to check this aspect of compatibility is generally missing from amplifier and loudspeaker data sheets, and so, if voltage-dependant current limiting is occurring with a particular loudspeaker/amplifier combination the following method will establish at what frequency and output levels the amplifier limiting is taking place.

Checking the amplifier
The loudspeaker is fed with a gated sine wave or tone burst in which the on/off time has been adjusted so that the mean power fed to the loudspeaker does not exceed the continuous power ratings of any of the units, when the ungated or continuous output of the amplifier corresponds to its maximum output. The signal input is then swept over the working range of the loudspeaker and the voltage waveform across the loudspeaker terminals is monitored on an oscilloscope for signs of signal break up which indicates the onset of limiting. Figure 2 shows the results of a typical test for an amplifier rated at 50W (equivalent to 70V peak to peak), into 8 ohms feeding both a resistive load and the loudspeaker load shown in Figure 1. The waveform into 8 ohms resistance is perfectly clean up to 70V peak to peak, but at 3.2 kHz the output to the loudspeaker can only be increased to 20V peak to peak before break up is clearly visible. This means that at around 3.2 kHz the amplifier will only deliver about 1/10th of its rated output to the loudspeaker because, even though the modulus of impedance at that frequency is still 7.1 ohms, the phase angle is 54 degrees and this combination of modulus and phase angle is sufficient to activate the protection circuit.

It is clear that the present method of specifying amplifier loads and loudspeaker impedances is unsatisfactory. Fortunately the importance of this subject is just beginning to be appreciated.

The dotted line, which is slightly above the minimum value of |Z| indicates the nominal impedance which is the value usually quoted by the manufacturer.

The preferred values for nominal impedance are 4, 8 or 16 ohms and some international standards on measuring high fidelity equipment state that the modulus shall not fall below 0.8 times the nominal value anywhere over the working range of the loudspeaker. For example, the minimum value for an 8 ohm system should not fall below 6.4 ohms.

Normally it is possible to relax this rule slightly without any ill effects, provided that the minimum value does not occur in the middle frequency range where programme energy peaks are most common.

Comment
Confusion often arises over the large variations in the modulus of the impedance over the working frequency range.

It is often incorrectly assumed that a peak in the impedance curve is necessarily associated with some mechanical or acoustical resonance which will adversely affect the sound quality. Impedance variations are due to the combined effects of the drive units and the dividing network and may be deliberately introduced by the loudspeaker designer. Increases in the modulus of the impedance reduce the transfer of power to the loudspeaker in order to produce a flat acoustic output for a constant voltage input.
KEF Products
As part of a seriously considered marketing policy, KEF offer a range of complete loudspeaker systems, loudspeaker kits and individual drive units.

These are three distinct market sectors each of which is supported by engineering, technical and promotional material.

Suggestions have been made that these three ranges of products could conflict with each other at retail level. This is not the case and indeed each sector is complementary.

KEF drive units are designed and engineered for optimum acoustic performance, consistency of performance and manufacture, coupled with long term reliability.

Each KEF drive unit is originally designed specifically for one enclosure. Having been tested and approved in that enclosure it is then offered for sale as a component.

Loudspeaker Drive Units
KEF drive units are sold to two market areas; to the consumer through retail outlets and to other manufacturers for use in systems of their own design.

The importance of the consumer market may appear obscure — after all what does the consumer gain by buying separate drive units and attempting to build his own loudspeaker? In the first place, individual drive units offer the consumer the opportunity of expressing individuality in technical and aesthetic design using proven components. The drive units appeal to the hobbyist, the potential designer and experimenter. Secondly, drive units represent a saving as the consumer can build a more complex system for a lower cost than a factory designed version.

Technical Information and Enclosure Design
In the dealer manual, KEF publish detailed data sheets on each drive unit which, combined with the comprehensive range of articles on various types of enclosures, enables the retailer to offer a basic, but comprehensive, advisory service to support his sales effort.

The sale of individual drive units meets the requirements of the genuine experimenter who has a degree of skill with his hands and is willing to undertake the task of cutting speaker panels and wiring to dividing networks. Kefkits on the other hand are designed for those who want to save themselves time and complicated woodwork.

Kefkits
Kefkits are an ideal mid point to which sales can be directed when a complete loudspeaker system may suit the customer but is too expensive and the alternative of assembling a system from basic components is too daunting. Kefkits have the advantage that customers know they can achieve the performance of proven factory-built systems. Each of the Kefkits is based on successful, commercially available, loudspeakers.

The Kefkit 1 contains all the components required to construct a bookshelf type system excluding the enclosure materials.

The Kefkit 3 is the larger of the two kits and is based on a three way floor standing system.

All drive units are mounted and connected via the dividing network. To ensure consistency and substantiate performance, every Kefkit is tested in a recommended enclosure against a laboratory maintained standard before it is finally packaged.

Kit building the KEF way provides a special guarantee of quality to the customer.

Drive Units and Kefkits give the retailer an opportunity of selling KEF products where higher quality is demanded by the customer but at a lower price than a complete loudspeaker system.

Display packaging, instruction leaflets, sales leaflets and point of sale material are available for all parts of the KEF product range. Special display units are available on a loan basis and details may be obtained from your local representative or by writing to the Product Manager at KEF.