TECHNICAL TALK

By JULIAN D. HIRSCH

● **THE NEW TECHNOLOGY:** Have you ever wondered how audio-equipment manufacturers manage, year after year, to develop new models with genuinely improved performance? In addition to the enhanced specifications we often find innovative features (such as digital FM tuners, various quadraphonic techniques, Dolby and other noise-reducing systems, and so forth) with little or no increase in price over the cost of earlier, less sophisticated equipment. Having spent more than twenty-five years in the design and development of commercial and military laboratory test equipment, I am especially impressed with the sophisticated circuits and components now becoming almost commonplace in consumer products. To some extent, these advances can be attributed to the advent of the transistor, but the causes go somewhat deeper than that.

The initial transition from vacuum tubes to transistors actually provided little, if any, improvement in performance. Early transistor-circuit designers fought a frustrating battle against noisy, unstable, low-level amplifiers with limited dynamic range and frequency response. Power amplifiers were notable for their low output, high distortion, and discouragingly short life. Perhaps the only clear advantage of those early transistorized products was their relatively cool operation. This was fortunate, since internal heating was the nemesis of the germanium power transistors—which were the only kind available at a reasonable price in those days.

The same technical problems faced the designers of commercial and military equipment, except that reliability was a paramount consideration. The solution was an expensive one, but not prohibitive for that market. They used silicon transistors. The small-signal types that could withstand high temperatures cost $25 to $30, and silicon power transistors, when they became available, were several times as costly. Fortunately, a rapidly expanding market soon lowered the prices of silicon transistors drastically. In a few years, epoxy-encapsulated silicon transistors (similar to those used in today's audio equipment), with characteristics technically superior to those of the early devices, were selling for as little as 25 cents. Similar advances in silicon power transistors made possible the modern stereo receiver, which has now surpassed in every respect the best vacuum-tube equipment.

In many cases it has been necessary to use two or three transistors to duplicate the function of a single tube, and a receiver that would have used perhaps twenty tubes in pre-transistor times might contain forty to fifty transistors. However, the savings in size and power consumption still encouraged designers to use large numbers of transistors to achieve results that would not have justified the use of an equal number of tubes.

The real "breakthrough" came with the development of the integrated circuit. An IC contains a number of transistors and diodes, plus the associated resistors (and often capacitors as well), on a single silicon "chip" about the size of a transistor. (In its packaged form, the IC is somewhat larger than a transistor, since it typically has about fourteen connecting leads instead of three, but it nevertheless occupies a small fraction of the space required by an equivalent number of individual components.) Although many IC's contain only ten to twenty transistor elements, it is now possible to make a single IC with hundreds of transistors on its small chip, and its cost will be only slightly more than that of a single transistor.

We have all seen the impact of these complex IC's in the electronic "pocket" calculators now selling for less than $100. It is perhaps not so clear how they affect the audio industry. But consider the "digital FM tuner," now available from several manufacturers. In its most advanced form, a digital

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Design Acoustics D-12 Speaker
Tandberg TR-1020 AM/FM Receiver
Philips 212 Record Player
Ortofon M 15E Super Cartridge

tuner replaces the conventional tunable "local oscillator" with a frequency synthesizer whose frequency (corrected for the 10.7 MHz i.f. frequency) is displayed on a four-digit readout of some kind.

Frequency synthesizers are not new. They have been used for years in communications and laboratory equipment, but, at prices ranging from $2,000 to $15,000, they have obviously not appealed to audio-component manufacturers. The development of suitable IC's, manufactured in large quantities for industrial and military users, has completely changed this situation. Furthermore, the prices of numerical displays and their associated IC drivers and decoders have plummeted because of the huge market for small electronic calculators. As a result, a digital tuner, which would have cost thousands of dollars only a few years ago and would have been virtually impossible shortly before that, now costs little more than the better conventional tuners.

Actually, the advances in linear IC's, rather than the on/off digital variety, have had an even greater impact on the industry. The earliest use of IC's in FM tuners was in the i.f. amplifiers, where they offered advantages in gain, stability, and limiting effectiveness. Next, the FM multiplex (stereo) demodulator, with its four to twelve transistors, was replaced by a single IC that out-performed the discrete components it replaced. Most recently, the phase-locked-loop (PLL) IC has been used in some tuners and receivers for superior low-distortion FM detection. The PLL, incidentally, is a basic component of most frequency synthesizers and was in fact originally developed largely for that application.

The well-known Dolby "B" noise-reduction system requires the use of a considerable number of transistors and other components, and this is reflected in the relatively high prices of a Dolby-equipped cassette recorder or FM tuner. An IC now in development will contain most of the Dolby circuitry, and should appear shortly in a number of moderately priced FM tuners and tape recorders. The original Electro-Voice quadraphonic decoding matrix was conceived and manufactured as a single IC. The latest full-logic SQ decoders, now made with discrete components, contain more than one hundred semiconductor devices and are therefore rather expensive. New IC's have now been developed that will permit the same job to be done with only three IC's at a correspondingly lower cost. The CD-4 quadraphonic discrete disc system now requires a rather complex demodulator, even with the use of several general-purpose IC's. As the market for these devices grows, we would expect to find them made up entirely of specialized IC's.

Developing a new IC can be so expensive ($50,000 to $100,000 is not uncommon) that only the existence or the potential of a mass market can justify it for a consumer application. Some old-time audiophiles tend to bemoan the growing popularity and watering down (as they see it) of their once-exclusive hobby. But it is only the entrance of components into the mass market that has enabled high-fidelity reproduction to reach its present state of technical sophistication.