The SPARTAN

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Transient Intermodulation Distortion

— by DAVE EVANS
Audio Products Manager

In the last discussion of TIM [August 1975; Ed] we noted that accurate reproduction of transients — sounds of very *short* duration — requires an amplifier with the following characteristics: (1) flat frequency response without ultrasonic peaks or oscillations, (2) wide frequency response, and (3) local negative feedback, rather than long feedback loops which have sufficient propogation delay to cause momentary overloading of the input stage by high frequency transients.

The first and last characteristics are generally accepted design philosophies, but the concept of needing a frequency response extending appreciably higher than the upper limit of human audibility has been slow to gain acceptance. Perhaps the reason is that engineers have traditionally tested and measured with single tones — usually sine waves — rather than with complex waveforms and combinations of frequencies which more closely simulate music. However, the recent acceptance of Intermodulation Distortion as a valuable yardstick of audible quality and a growing awareness of transient response and distortion as additional contributors are forcing a rethinking of old ideas.

Two of the principles used for justifying an extended frequency response are as follows: (1) musical instruments produce harmonics which often extend well beyond 20 kHz. Although such requencies cannot be directly perceived by the human ear, studies have indicated that the sound quality is nevertheless audibly altered when an amplifier bandwidth is inadequate to reproduce them, and (2) musical transients and the rapid rise time at the beginning of sounds produced by some musical instruments, are analogous to square waves which require a bandwidth much greater than the fundamental frequency for accurate reproduction.

The kind of study referred to in (1) above is one in which the upper frequencies are rolled off at a frequency several KHz above the tested upper limit of the subject's hearing. It is not certain whether the results are a function of the hearing system or of the amplifier. For instance, if an amplifier rolls off (down 3 dB) at 20 KHz, there is 45% phase shift at 20 KHz and some phase shift well below frequency. If the amplifier rolls off too rapidly — say more than 6 dB per octave — there will be 'ringing' which is one cause of TIM; an audible distortion.

Turning to item (2), a bandwidth of 10 times the fundamental frequency is necessary to accurately reproduce a square wave. The question then is what square wave frequency must an amplifier pass in order to assure accurate music reproduction? Expert opinion varies, but from a low of 4 KHz to a high of 20 KHz includes most typical answers. Thus, an *ideal* amplifier should have a response to at least 40 KHz and perhaps 200 KHz.

What folly, some will say, to talk of 40 KHz amplifiers when the required bandwidth for AM is 50-7500 Hz, and 50-15,000 Hz for FM (U.S. standards). Is it, in fact, relevant? I happen to think so. To begin with, the FCC does not specify a maximum audio frequency for AM nor FM, but that opens up a whole new field of inquiry beyond the scope of this article.

There is no reason why a wide-band audio signal should not be maintained right up to the input of both AM and FM transmitters although it is more difficult to do if the telephone company is in the circuit. What, then, is to be gained by all this bother?

Let's take an example — admittedly extreme — but fairly easy to mentally visualize; a cymbal has a fundamental frequency of about 680 Hz, and harmonics extending to above 25 KHz. In fact, the harmonics at 18 KHz have an amplitude equal to the fundamental! Let's face it; we *cannot* broadcast the sound of a cymbal crash with total accuracy using existing standards. But that's *not* the reason a cymbal crash sounds like the clanging of garbage can lids on many radio stations. The reason is that the transients in the cymbal crash and much of the harmonic content was degraded or destroyed long before the signal got to the transmitter — perhaps as far back as the phonograph cartridge or turntable preamplifier.

The essential point of this entire series is that the various forms of audio degradation — harmonic distortion, IM, TIM, bandwidth limiting, and other factors — are *additive* and *irreversible*. There are limitations in the transmitting standards which will cause some audio degradation, of course, but if the audio to the transmitter has a full frequency response the resulting broadcast will have an appreciably cleaner, crisper sound quality than you may have thought possible.

Now, for a moment, consider an all too typical broadcast production studio: a discarded or second-rate audio console feeding an ancient reel recorder from which dubs onto cart are made for use in the main control room. Sometimes music is put on cartridge in the same production studio. The resulting commercials and music sound audibly inferior to control room originations. The distortion and other limitations from the production studio amplifiers are irreversible and will get worse as the cartridge audio passes through the system.

The production console and recording equipment should actually have *less* audio degradation than the control room console if recorded announcements are to sound comparably clean and bright.

(Continued Back Page)

Product Of The Month

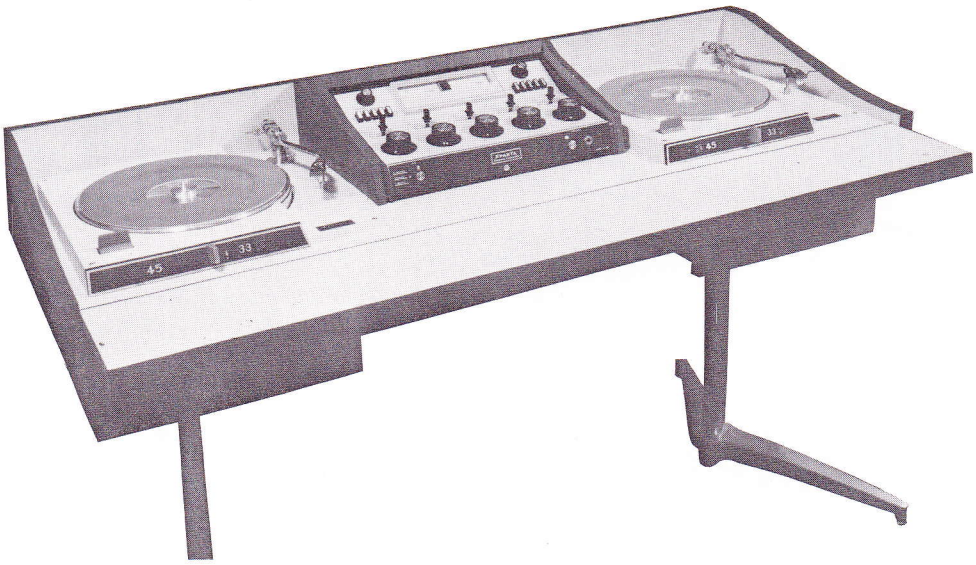
The discotheque business is booming across the country again, after an apparent leveling off about four years ago. A new development or two are apparent in this resurgence: discotheques are springing up belatedly in smaller cities, and orders for Sparta Models ASC305B and ASC305C are coming from enterprising DJs who want a portable Audio Control Center with which to 'moonlight' their own discotheque shows at parties or existing dance spots. The first such requests came from Los Angeles individuals about eighteen months ago, but more recently the requests include DJs in towns of 100,000 or so between the Rockies and Appalachians.

The history of the monaural and stereo Remote/Studio Audio Control Centers made by Sparta goes back to the 4-mixer Model A50, introduced in 1961 [see Jan-Feb 1974 "Spartan"; Ed]. Today the enormously popular 5-mixer units are available in four different models:

1) AC155B, monaural, with ST12 standard four-pole Turntables, ST220 Tone Arms and Sparta 220S pickup cartridges, Model 1050 5-mixer console with standard attenuators $1,700
2) AC155C monaural, with GT12 deluxe synchronous Turntables, ST220 Tone Arms and Sparta 220S pickup cartridges, Model 1017 5-mixer console with precision step attenuators $1,945
3) ASC305B, stereo, with ST12 standard four-pole Turntables, ST220 Tone Arms and Sparta 220S pickup cartridges, Model 1030 5-mixer console with standard attenuators .. $2,025
4) ASC305C, stereo, with GT12 deluxe synchronous Turntables, ST220 Tone Arms and Sparta 220S pickup cartridges, Model 1035 5-mixer console with precision step attenuators $2,320

OPTIONAL EQUIPMENT includes the BL5 Bench/Lid combination which fits any of the four models, the US5 Utility Shelf, MIC6 microphone (EV635A) with gooseneck to complete the Remote/Studio Audio Control Center for broadcast.

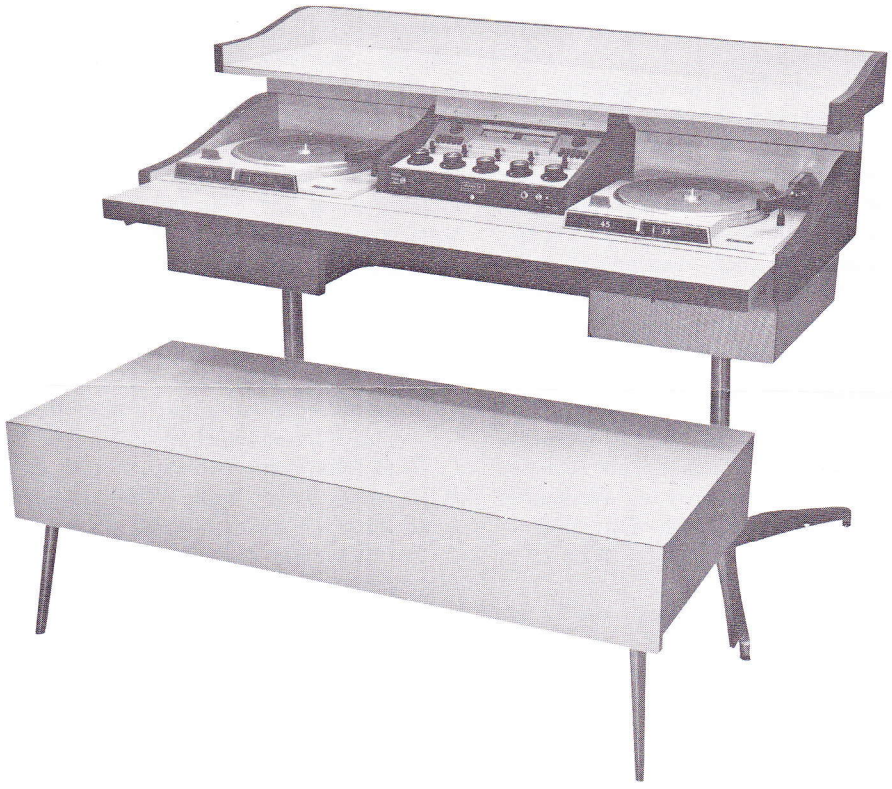
For either broadcast or disco use, the Sparta Monitor Amplifier series (mono or stereo, with or without cue) and SP30 and SP40 Speaker Systems [see September 1975 'Spartan' "New Products" for complete SP30 and SP40 specs; Ed] complete a very portable, sturdy, and top quality system.



The ASC305C (above) is enjoying renewed popularity among discotheques and freelance DJs who are moonlighting dance music for parties and such. The disco business is booming again — particularly in smaller cities — and where sturdiness, top performance, and portability are concerned, the stereo ASC305B or ASC305C models, with optional equipment, have proven time and again to suit the need.

Below, the ASC305C is shown with BL5 Bench/Lid in operating position, and with US5 Utility Shelf for tape cartridge equipment, reel/reel machine, or other aids. The work surface in front of console and turntables folds down for transport, and the BL5 provides full cover for the compact unit.

Companion items for either studio or disco use include monitor amplifiers and fine quality speaker systems. Cue speaker is built into both mono and stereo models. — Sparta Photos

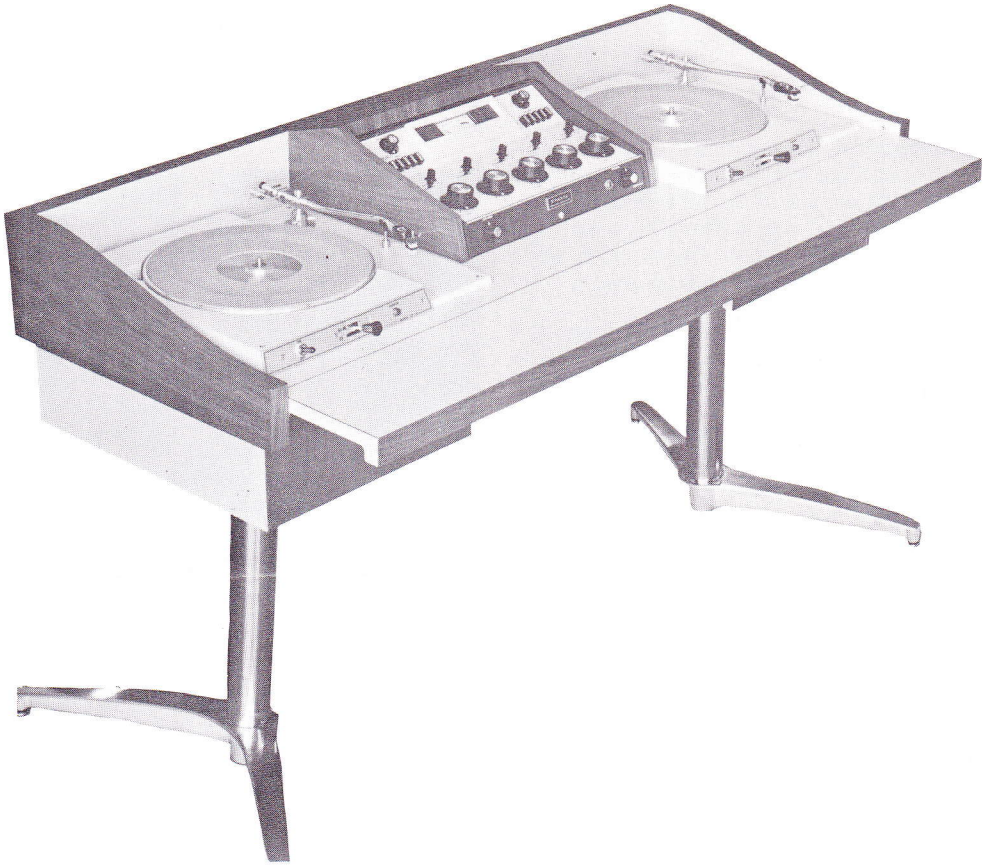


The AC and ASC units do their job in a 54"W x 26"D space, 34"H overall, with the Utility Shelf adding another 7.5" in height if used.

From the discos and freelancers using the Sparta portable units, we hear that they do the discotheque job beautifully . . . with nothing more to add except a lighting system (which we don't supply). In radio production work, where the AC or ASC can double as a complete remote broadcast unit, no comparable equipment appears to be available to the broadcaster.

Tech Tips

— by RIGO FELIX
Mgr. Customer Service



The AC155B with ST12 Turntables, ST220 Tone Arms, Model 1015 Console.

THYRISTOR semiconductor starting circuits have commonly come to replace relays as turntable remote start devices.

When starting inductive loads such as turntable motors, there is the requirement of switching a large amount of current. When relays are used, 'contact bounce' will usually occur, causing RFI and deterioration of contact surfaces. Most often this produces audible popping on the monitor or program channels.

A typical RMS current for synchronous motors is 300 mA, with peak surge current on the order of 1.0 Amp. The typical RMS current for four-pole motors is 550 mA with peak surge current up to 1.5 Amp, depending upon motor loading.

Two circuits which have been used successfully are the 'hybrid relay' and the 'optically isolated' solid state relay. The basic schematics are shown as Figures I and II, respectively. Care should be taken in conformation of the circuit to load requirements.

Input power is on the order of 150-400 mW, allowing low current switching within the console relay system. A high amount of isolation between input and output results because of the indirect gating used.

These devices, designed for between 10 and 100 *million* uses, are available in a variety of encapsulated forms from several reputable manufacturers; some may be had with zero voltage turn on and zero current turn off at slightly higher cost, further minimizing RFI and EMI.

Installation should be done at the turntable, keeping AC away from audio circuits.

If you enjoy experimenting and making things yourself, the circuit in Figure III will perform adequately.

Figure I

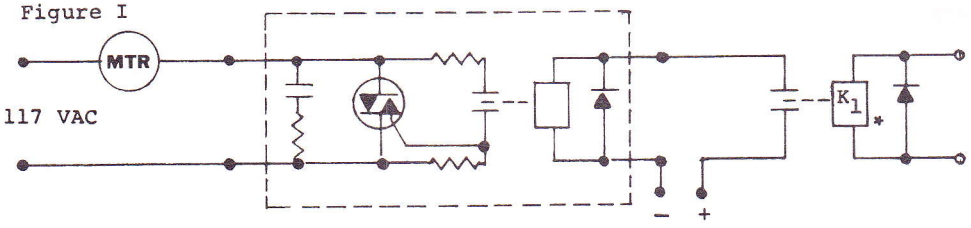


Figure II

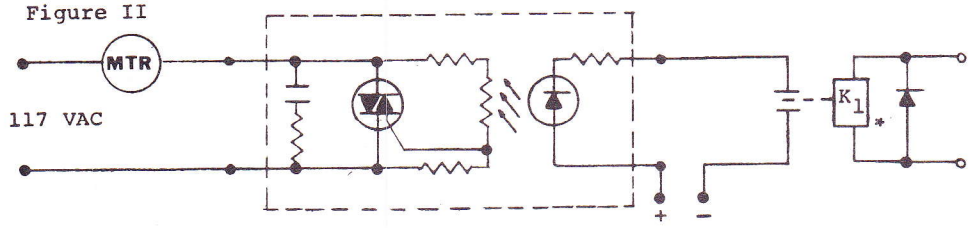
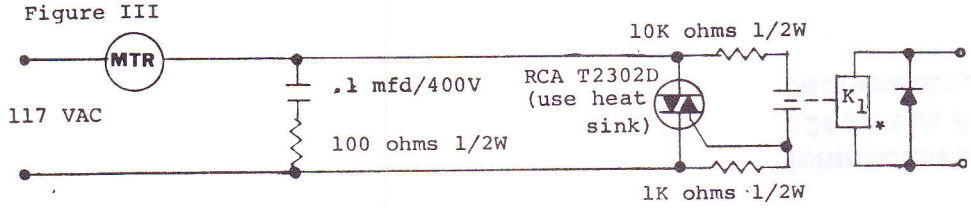


Figure III



*K_1: relay in typical console.

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T.I.M. *(From Front Page)*

Additionally, some audio processing may be required in the production studio to 'balance' the sound of recorded and live announcements. However, the subject of audio processing is so broad that we'll have to save it for a later series. Incidentally, your comments, test data, or other information regarding the foregoing subject matter is welcome and may provide enough material for a followup article.

See you again here in The SPARTAN.

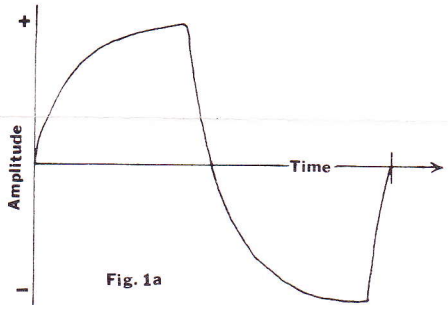


Fig. 1a

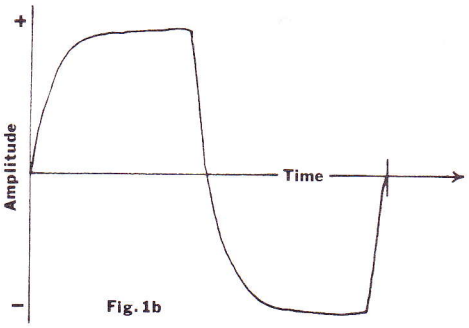


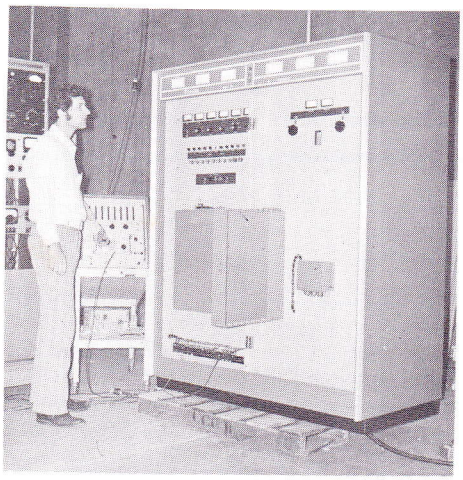
Fig. 1b

Figures (1a) and (1b) show 10 KHz and 5.5 KHz square waves respectively. Each has passed through a simple low pass RC filter which is 3 dB down at 15 KHz.

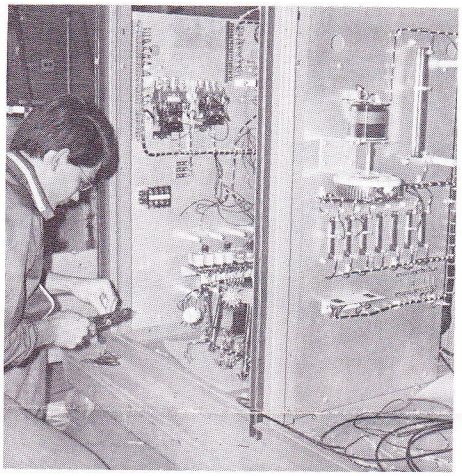
OVERSEAS SCENE

Educational Enrichment Center, the Sparta rep firm in the Philippines headed by Felix Zamora, will install two complete radio stations — one at the University of the Philippines at Los Banos, and the other at Central Mindanao University.

Sparta will ship well over 1,000 items to Zamora at EEC for the projects, including: two Model 705B 5 kW AM Transmitters (below Bob Hopkins, Checkout Supervisor, takes a final look at one of them); towers, guys and ground system wire; complete monaural studio equipment and limiting equipment; speakers; test and repair equipment; spare parts; batteries; remote broadcast equipment; installation tools, wire, connectors and other hardware. The order to Zamora was for two completely turnkey installations — even to a pair of 4WD vehicles!!



The Amalgamated Wireless Australasia, Ltd order is being completed [see September 1975 'Spartan', "Overseas Scene"; Ed] with production of the new Sparta Model 705C 5 kW AM Transmitter (below). Shipments of the five 705Cs have begun as you read this.



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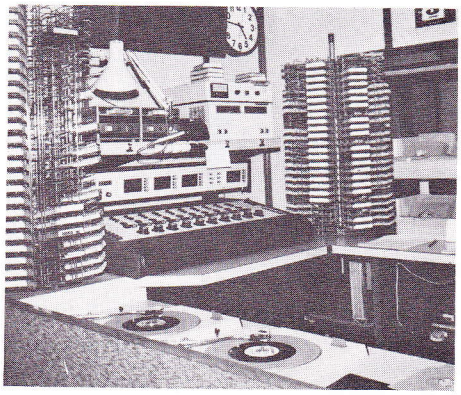
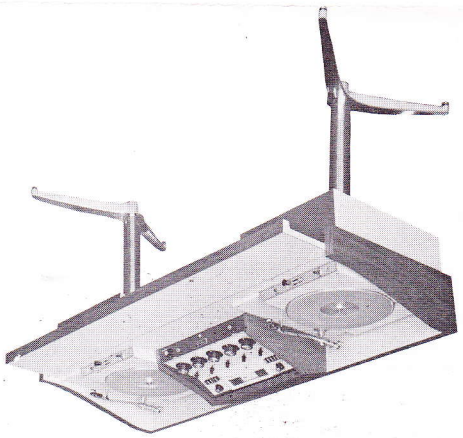


KVOX ("Let the Sound Shine In") in Moorhead, MN is using ten mixers in their Centurion I Console for 24-hour rock, in this standup control room operation. CE Steve Terhaar reports all hands satisfied with the customized and functional-looking setup.

—KVOX Photo



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