Automated system for acoustic research

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An automated system is described for stimulus presentation and response collection in psychoacoustic research. The system is capable of producing rapidly and precisely a wide range of discrete frequencies.

Considerable attention has been directed toward the development of flexible, automated, and programmed systems for presentation of auditory stimuli. Doorne and Sanders (1968) have outlined several preliminary requirements that can be applied to such a system: (1) SIGNALS—(a) An entire test session should be programmable. Signal choice, presentation duration, intertrial interval, and number of trials should be variable. (b) Simultaneous, overlapping, and/or successive signal presentations should be possible. (c) Large sets of alternative signals should be available. (d) Presentations should be paced either automatically or by the S. (e) Peripheral equipment should interface easily. (2) RESPONSES—Subject responses and time checks should be available for on-line display and/or accurately recorded for later processing.

Some of the above criteria were met by Ayres, Crist, and Juster (1969), who provided pure tones of different frequencies with a single oscillator according to a hardwired program. The same problem may be expanded with a fully automated system

producing many tones in different sequences around several variable, specified base frequencies. This paper describes such a system. The system may be expanded by using digital computers to encompass fully the model proposed by Doorne and Sanders. The major disadvantages to such expansion are the difficulty of access to digital computers for on-line control and the high cost of software development.

Figure 1 shows a block diagram of the entire system as applied to several areas of auditory research. In this configuration, signals are presented to the S through electronic switch (I) (Grason-Stadler, Model 829 D), which is controlled by an interval timer (Grason-Stadler, Model 471-1). The timer is controlled through a time-delay relay by the main stepping switch. The delay provides constant intertrial interval and allows signal source (I) time to stabilize before presentations. The stepping switches have multiple poles so that several control and count functions can be carried on in step. Electromechanical operations during tone-on intervals may be avoided by appropriate interval selection on the time-delay relay. Selection of sets of resistor bridges to produce many tones in discrete sequences around several base frequencies from signal source (I) is preprogrammed.

Details of the frequency-determining networks for use with the signal source (I) (General Radio, Model 1311-A r-c oscillator) are shown in Fig. 2. Resistors A_i and B_i , connected to the main stepping switch (Fig. 2a), determine the specific frequencies around the base frequency. Resistors C_i and D_i , connected to the base frequency selector switch (Fig. 2b), are set in parallel with Resistors A_i and B_i . Maintaining a constant resistive input to the

Fig. 1. Block diagram of the automated control system.

oscillator (Fig. 2c) minimizes oscillator stabilization time after each frequency change.

Selection of resistor values and calibration of the networks is straightforward if multiturn potentiometers are used (such as Bourn's miniature trimpots). All variable resistors may be preset with an ohmmeter by the relationship $R(\Omega) = 1.6 \times 10^6 / \text{frequency(Hz)}$, and $R(\text{parallel}) = R_1 \times R_2 / R_1 + R_2$. These preset values may be adjusted to the exact frequencies required by use of an electronic counter. If the oscillator output voltage is monitored with an ac voltmeter, one resistor may be varied to approach the desired frequency, and the other adjusted to restore the output voltage to the predetermined level and to attain the frequency. Calibration this way eliminates the need for an ohmmeter to constantly match the resistance of each half of the bridges. The resulting frequencies are highly stable and repeat accuracy is excellent, ± 0.1 Hz or better after 1 h warm-up.

Since the predetermining counter changes the base frequency switch after a preset number of trials, any number of trials at a base frequency and any selected set of base frequencies may be

* Replace C₂ with a 600 pf. capacitor

Fig. 3. Beat-frequency oscillator modification.

Fig. 2a. Main stepping switch and resistor network.

Fig. 2b. Base frequency stepping switch and resistor network.

Fig. 2c. Constant input resistors.

Oscillator switch contact points 301F, 201F, and 101F refer to S101 on the schematic in the General Radio 1311-A Audio

Oscillator switch contact points 301F, 201F, and 101F refer to switch S101 on the schematic in the General Radio 1311-A Audio Oscillator Instruction Manual.

presented automatically. Ss' responses are channeled through corresponding poles of the main stepping switch to counters (e.g., if Positions 5, 19, 21, 37, and 51 on the stepper have the same frequency setting, all five of these are channeled to the appropriate counting device or data channel). The resistor networks are set on interchangeable patchboard panels (such as Mac Panel type). The stepper points are wired to rear pin connectors. Changing panel faces holding different resistor networks enables change of frequency settings and/or presentation sequences with a minimum of down-time. An extra level of paneling may be provided between the resistor networks and the stepper interface for changes in presentation order alone.

The system outlined here is flexible and, in general, meets the Doorne and Sanders criteria. Minor changes can adapt it for a variety of problems in auditory research. No modifications are needed for investigations of diotic, dichotic, or monaural masking, beat phenomena, and fusion. Signal detection paradigms require a modification of the Grason-Stadler electronic switches to ensure simultaneous switching of corresponding channels (Tomsic & Elfner, 1969).

A similar modification can be applied to a beat-frequency oscillator (General Radio, Model 1304-B) using a capacitor network in parallel with the fine tuning capacitor (see Fig. 3). While this modification is successful, it is also less stable than modification to the r-c oscillator. The capacitors are highly interactive with lead lengths. Repeat accuracy is no better than ± 5 Hz at base frequencies below 2000 Hz, and decreases as base frequency increases.

Either system can be assembled at minimal cost, since most of the components are common items in acoustic research laboratories.

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NOTES

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