Reception and transmission of infant vocalizations with dedicated telephone lines

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A remote control home amplifier is described that allows the investigator to use dedicated telephone lines between the laboratory and the home to record infant vocalizations and provide auditory stimulation to the infant. The procedure allows daily test sessions with the infant, and several infants can be studied each day with one set of laboratory equipment.

Longitudinal research with infants brought to a laboratory is plagued with problems associated with acquiring test or observation sessions when the infant is in an optimal physical and psychological state. These problems prompted our development of a technique for studying infant vocal behavior at cribside in the infant's home at times selected by the mother. The equipment placed in the home consists of an amplifier unit and a microphone stand to which a microphone and speaker are attached.

The remote home unit is designed to: (1) pick up, amplify, and couple to a telephone line the vocalizations of an infant; (2) amplify and present audio signals received from the laboratory over a second telephone line; (3) be activated/deactivated by remote control from the laboratory by signals over the second telephone line; and, (4) be unobtrusive, with a provision for local deactivation by the infant caretaker.

HOME AMPLIFIER UNIT

A block diagram of the device is shown in Figure 1; Figure 2 provides a circuit diagram. Each audio channel consists of a two-stage amplifier. The first stage has a National Semiconductor LM381 low-level preamplifier (IC1); the second stage is based on the National Semiconductor LM 379 6-W stereo amplifier (IC2). Amplifier gain is primarily controlled by the variable resistors in the feedback loops of the LM 379. This amplifier configuration provides up to 70 dB of gain at $\leq 0.2\%$ total harmonic distortion from 45 to 4,000 Hz (half-power). Output rolls off at about 5 dB/octave above 4,000 Hz, and the noise floor is about 50 dB below a typical signal.

Power for the system is provided by feeding 117 V ac

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(fused at 2.5 A) to a transformer (Stancor P8668). Transformer output is fed through a bridge rectifier to produce 20.4 V dc for (1) a voltage regulator (National

Figure 1. Block diagram of the home amplifier.

Figure 2. Circuit diagram of the home amplifier.

Semiconductor LM 340T-15) that provides 15 V dc to the amplifier, preamplifier, and relays, and (2) a voltage regulator (Sylvania ECG 966) and resistive voltage splitter that provide 9.0 V dc to the tone detectors.

The tone detectors provide remote on-off control by responding to frequencies transmitted over the phone line from the laboratory at a signal level of 4 dB W. The ground level output of the "on" detector (IC3) operates and latches in Relay 1, which in turn switches the dc supply to the amplifiers. Output of the "off" detector (IC4) actuates Relay 2, which in turn unlatches Relay 1 and thereby removes power to the amplifiers. The detectors, which are always powered, are based on NE 567 phase-locked loops and are independently variable over a range from 200 to 4,000 Hz. Sensitivity of the detectors is 20 mV.

The dc power to the amplifiers may also be shut off by simultaneously opening two switches (S1 and S2 in Figure 2). Provision of two separate switches to be simultaneously operated serves to prevent accidental shut-off by a child. A pilot lamp on the top of the unit, adjacent to the pushbuttons, is lighted whenever the amplifiers are powered.

The amplifiers are transformer coupled to dedicated telephone lines provided by Northwestern Bell Telephone Company. Each dedicated line is hard wired so that it does not pass through the switching network of the telephone exchange. Each line is balanced, presents a 600-ohm impedance, has a passband of 100 to 5,000 Hz, and has a noise floor approximately 45 dB below the maximum allowable signal of 8 dB W. Signal loss is a function of the length of the telephone line. A 4-mile line, the longest in our research, has a 25-dB loss.

All components (see Table 1) are housed in an aluminum box, 45 x 13 x 19 cm. The cover of the box is attached with Phillips machine screws to prevent opening by a small child. Components are arranged so that any small object inserted through a ventilation hole does not provide an electrical shock. The chassis, cover, and cable to the telephone terminals are grounded, providing shielding for radio frequency interference. A 60-Hz slot filter may be placed on the input side of transformer T1 (see Figure 2), but it is not essential due to the bandpass characteristics of the telephone line. Costs, excluding the housing, are about \$70/unit.

In our installation, a Sony ECM 200 Electret microphone is mounted on a gooseneck and attached to the boom of a microphone floor stand that is placed at the foot of the crib. An Advent 400 speaker is attached to the microphone stand, and cables from the microphone and speaker run down the microphone stand to the amplifier unit placed under the crib. This particular microphone and speaker provide a flat frequency response over the range of signals transmitted over the telephone line.

Table 1
Parts List

Preamplifier
C1, C2 = .1 microF
C3, C4 = 10 microF
C5, C6 = .001 microF
R1, R2 = 100-kohm potentiometer
IC1 = LM381
Amplifier
C7, C8 = 5 microF
C9, C10 = .1 microF
C11 = 250 microF
C12, C13 = 200 microF
R3, R4 = 2 kohm
R5, R6 = 100 kohm
R7, R8 = 100-kohm potentiometer
IC2 = LM379 (in heat sink)
Detector
C14 = 10 microF
C15, C18 = 4.7 microF
C17, C20, C21, C22 = .1 microF
C16, C19 = 1.0 microF
R9, R15 = 10 kohm
R10, R12 = 100 kohm
R13 = 3 kohm
R14, R16 = 5-kohm potentiometer
IC3, IC4 = NE567
IC5 = LM3900
K1, K2 = 2-A DPDT relay, Potter & Brumfield R10-E1-Y2-J2.5K
T1 = 600-2,000 ohm, Stancor A-8078
T2 = 8-600 ohm, Calectro D1-726
S1, S2 = NC pushbutton

APPLICATION

The apparatus was developed to study the development of infant vocalization during the first 6 months of life and to study the infant's vocal response to the playback of the utterance she/he just produced vs. an utterance she/he produced on a previous day. An International Tapetronics RPD unit provides immediate playback of the prior 1.26 sec of the infant's vocalization (NAB Type B cartridges were modified to allow a 29-cm loop of tape). To play back utterances from a previous day, loops of the same length are prepared from recordings and presented with a three-deck cartridge playback device (International Tapetronic 3-D reproducer). Both of the above units are designed to meet commercial broadcast standards and are highly reliable and easy to service. To assure that the telephone lines cannot be used by unauthorized personnel, a removable metal panel with hasp and padlock are installed over all telephone terminals in the laboratory, and the tone generator that actuates the home devices is placed in the "off" frequency.

The system can be used in a variety of research settings dealing with the auditory stimulation of infants and the recording of vocal responses. Before employing the technique, however, the reader should carefully

evaluate whether the advantages outweigh the disadvantages.

Disadvantages of the system include (1) background noise in the home, which requires that the microphone be placed within 18 in. of the subject, (2) the passband limits of the telephone lines and noise in the home that limit the acoustical analysis of the vocal samples, (3) telephone line distance from the laboratory to the home, which should be limited to about 4 miles unless more than a 25-dB loss can be tolerated, and (4) monthly telephone charges, which are calculated on the basis of four lines per home installation (two from the laboratory to the exchange and two from the exchange to the home), plus an initial installation fee that can exceed \$100.

Advantages include the nonintrusive, low-risk, ecologically valid quality of the data collected. The technique allows the collection of a large amount of data from each infant, so that research designs predicated on considerable data can be employed. Daily or twice-daily sessions can be conducted with the infant over a period of weeks while maintaining good cooperation from the parent. Finally, the technique allows the use of several relatively inexpensive field units with one set of laboratory devices.

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