WASHINGTON SEA GRANT PROGRAM

CIRCULAR NO. 70-7

A UNIVERSAL INTERFACE AMPLIFIER FOR COUPLING AN ECHO SOUNDER TO A MAGNETIC TAPE RECORDER

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June 15, 1970 • University of Washington
College of Fisheries • Fisheries Research Institute

WSG 70-3

DIVISION OF MARINE RESOURCES
UNIVERSITY OF WASHINGTON 98105

Prepared under the
National Science Foundation
SEA GRANT PROGRAM

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This investigation was supported
by NSF Grant GH-66
under the SEA GRANT Program

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Sea Grant encourages the interdisciplinary approach for the solution of theoretical and practical problems of importance to the fishing industry and management agencies.

The present report represents a step toward quantification of acoustical signals which can be used for estimation of the stock size of fish populations.

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INTRODUCTION

A universal interface amplifier was designed and constructed recently as part of the University of Washington's Marine Acoustics Program under the National Sea-Grant College Act. James H. Green, an electrical engineer employed by the Program, designed most of the circuitry and Edmund P. Nunnallee, a fishery biology undergraduate also employed by the Program, did most of the construction and layout. The device converts the frequency and amplitude of the video output of an echo sounder, the signal that represents target information, to a frequency and amplitude that is acceptable to a standard stereophonic tape recorder (Fig. 1). The unit was designed for ease of operation and utility. Only two external switch settings are required for its operation. The first switch selects the echo sounder output frequency that is to be converted and recorded on magnetic tape. The second switch selects input attenuation so that an acceptable output voltage level for the tape recording system is obtained.

CIRCUITRY

The circuitry of the universal interface amplifier consists of six basic parts: a video attenuator, a video amplifier, a chopper, an output amplifier and low-pass filter, a bipolar trigger, and a microphone amplifier. A block diagram is shown in Fig. 2 and a complete schematic diagram in Fig. 3.

Video Attenuator

The video attenuator has an input impedance of 11.11k ohms to ground. Position 5 of the attenuator switch, the off position, grounds the input of the video amplifier without changing the input impedance of the interface amplifier. Position 1 of the switch connects the video input jack directly to the input of the video amplifier. The remaining positions of the switch reduce the video input signal to 0.1, 0.01, or 0.001 times the input voltage. For attainment of the greatest signal to noise ratio, attenuator settings other than X 1 should be used only when the video input voltage is too great for undistorted output of the interface amplifier.

Video Amplifier

The video amplifier utilizes a Fairchild µA 709 C integrated circuit. This semiconductor device has differential input capabilities and input and output frequency compensation availability. In this particular application the positive (noninverting) input of the integrated circuit is used to adjust the DC offset of the output of the video amplifier to zero

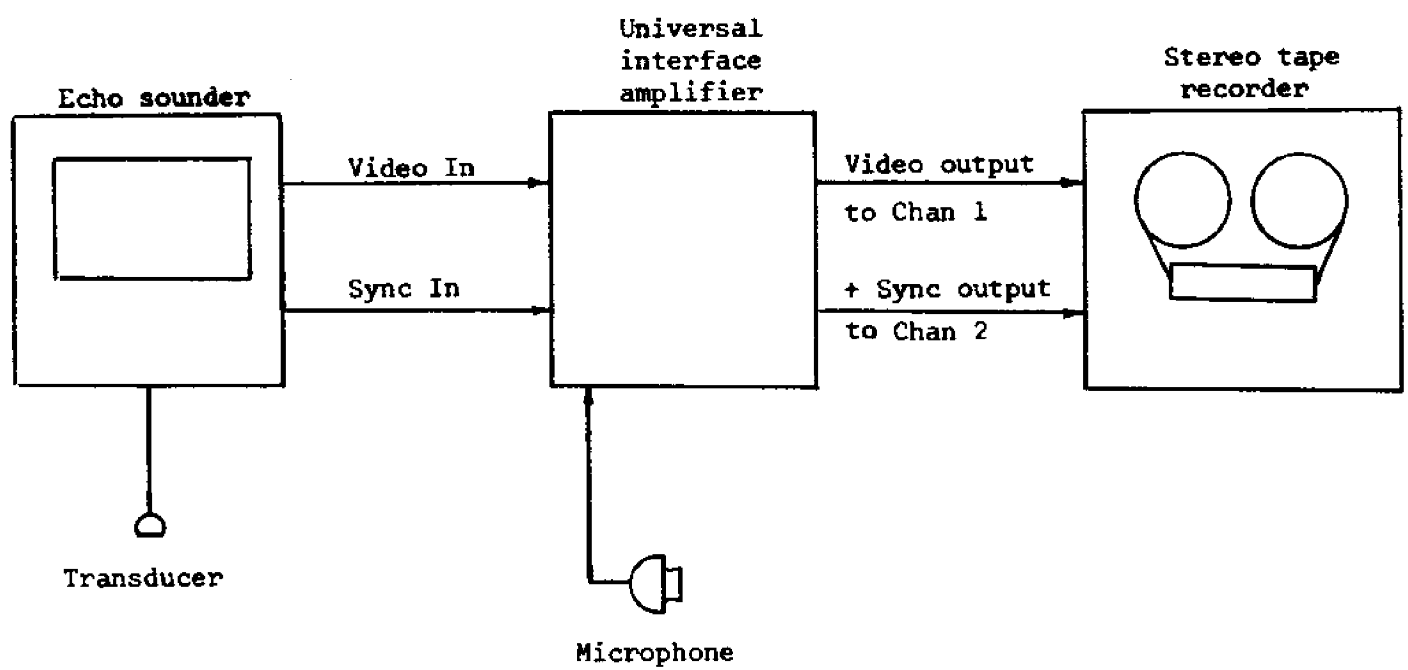

Fig. 1. Diagram of basic echo sounding-recording setup.

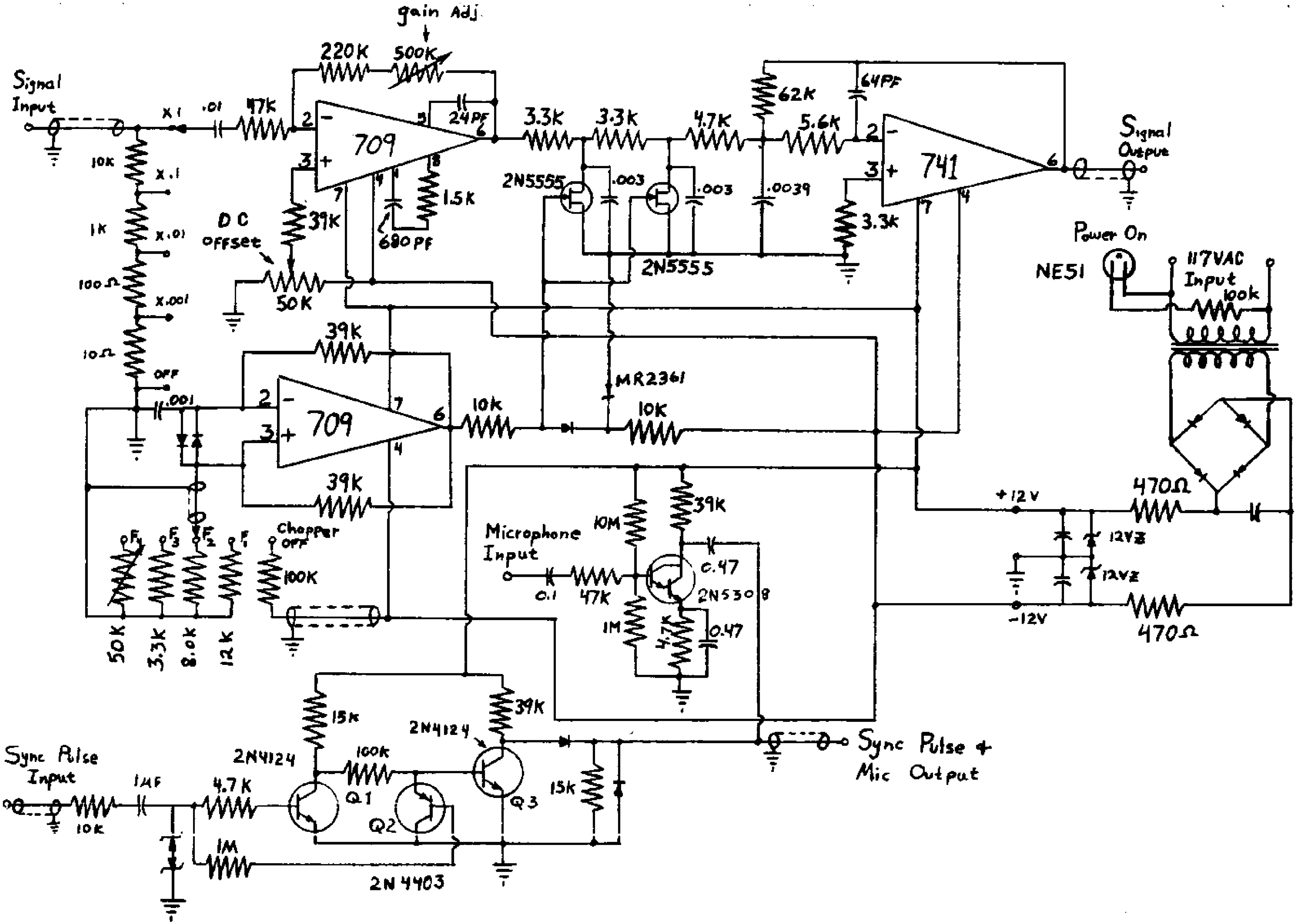

Fig. 3. Universal interface amplifier, Model LBB-1.

voltage by selection of the necessary negative bias level. At this setting the maximum signal output without distortion of positive or negative peaks can be obtained. Input frequency compensation (1.5k ohms in series with a 680 pf capacitor between pins 1 and 8) and output frequency compensation (a 24 pf capacitor from pin 6 to pin 5 of the device) were selected to give a flat frequency response from DC to about 600 kHz.

Chopper

The chopper utilizes a μA 709 C integrated circuit that is operated as an astable multivibrator. Feedback is applied through a pair of 39k ohm resistors from the output to the differential inputs of the integrated circuit (pin 6 to pins 2 and 3). When the output of the chopper becomes positive, feedback to the noninverting input, pin 3, reinforces the tendency until the device reaches saturation and no further change in voltage is possible at the output. As the output voltage of the chopper is going in the positive direction, feedback is also applied to pin 2, the inverting input. An R-C voltage divider consisting of the 39k ohm resistor from the output to pin 2 and a .001 μf capacitor from pin 2 to ground determines the feedback voltage applied to pin 2. During the period of rapid voltage change at the output of the chopper, pin 2 is effectively grounded through the capacitor until saturation of the device is reached. After saturation, the output of the chopper is stabilized at a voltage near +V, the positive power supply voltage. As the .001 μf capacitor charges toward the voltage at pin 6, the output of the chopper, the voltage on pin 2 approaches that on pin 3 and the integrated circuit comes out of saturation. At this point, the output voltage of the chopper begins to decrease and the voltage on pin 2 becomes positive with respect to that on pin 3 because of the discharge of the .001 μf capacitor through the 39k ohm feedback resistor. The result is that the negative tendency of the amplifier is reinforced by the feedback to the noninverting input, pin 3, and cutoff is quickly reached. The output of the chopper then stabilizes near -V, the negative power supply voltage, and the cycle repeats itself. A pair of diodes across the input of the device provides overload protection. The rise time and fall time of the chopper waveform is limited by the slew rate of the integrated circuit device and is in the order of 1 or 2 μsec.

Frequency control of the chopper is accomplished by setting pin 3 of the integrated circuit to a specific maximum voltage that is determined by a divider consisting of the 39k ohm feedback resistor and a resistor on the frequency selector switch. The maximum voltage on pin 3 determines the length of time that the .001 μf capacitor on pin 2 must charge or discharge before the differential voltage between the two pins approaches the normal range for linear operation and the integrated circuit device can change state.

The output of the video amplifier is chopped by being effectively shorted to ground during the positive portion of the chopper waveform. This is done by the switching of two field effect transistors on and off at the chopper rate so that they act as electronic switches that open and close between the video amplifier output and ground. When the chopper is disabled, in the off position of the frequency selector switch, these transistors are biased off and the video signal is no longer chopped.

The video signal is chopped at a rate 6 kHz higher than the input frequency for the 38.5 kHz range and 10 kHz higher than the input frequency for the other ranges. The video frequency, which is 100 per cent amplitude modulated by target information, the chopper frequency, and the sum of and difference between these two frequencies are all fed into the output amplifier. A low pass filter that attenuates all frequencies greater than about 12 kHz (Fig. 4) allows only the difference frequency, amplitude modulated by target information, to reach the output jack. In effect, the amplitude-modulated carrier frequency received by the video amplifier is converted to frequencies that can be recorded on magnetic tape without sacrifice of target information.

Output Amplifier and Low Pass Filter

The semiconductor device used for the output amplifier-low pass filter stage is a Fairchild µA 741 integrated circuit. Resistive and capacitive input and feedback networks are used to operate the device as a low pass active filter with rolloff starting about 12 kHz. Above this frequency the attenuation of the filter increases at about 45 dB per decade (Fig. 4, curve 1).

The echo duration from a single target will be very nearly equal to the width of the sonic pulse produced by the echosounder. The period or duration of a waveform and its frequency are reciprocals. Therefore, the necessary frequency response of the output amplifier must be at least equal to the reciprocal of the shortest echo period expected. Echo sounder pulse durations shorter than 0.1 msec are not anticipated at the present time for the type of work done by the Marine Acoustics Program. The frequency corresponding to a 0.1 msec pulse width, $F_i = 1/T_i$, equals 10 kHz. Twelve kHz was chosen as the cut-off frequency of the output amplifier because the highest frequency of the target information calculated from the transmitter pulse width will be no greater than this value.

Bipolar Trigger

The bipolar trigger circuit was designed to convert pulses of any voltage greater than 1 v and of either polarity to a squared positive pulse. A pulse produced by the echo sounder during the time of the transmitted pulse is used as a timing reference when the taped echo soundings are analyzed. Pulses received by the circuit are connected to the bases of transistors Q1 and Q2 (Fig. 3). A positive pulse will cause Q1, an NPN transistor, to turn on and effectively short the base of Q3, through a 100k ohm resistor, to ground. The second transistor, Q2, will receive the positive pulse on its base also but will be reverse biased and remain off. Normally the output transistor, Q3, is turned on, but will turn off when its base voltage approaches ground potential and the collector will go to about +V. When a negative pulse is applied to the input, Q1 is reverse biased and remains turned off. The base of Q2 is forward biased, however, and the transistor turns on, effectively grounding the base of Q3. Transistor Q3 will turn off and produce a positive pulse at the pulse output jack.

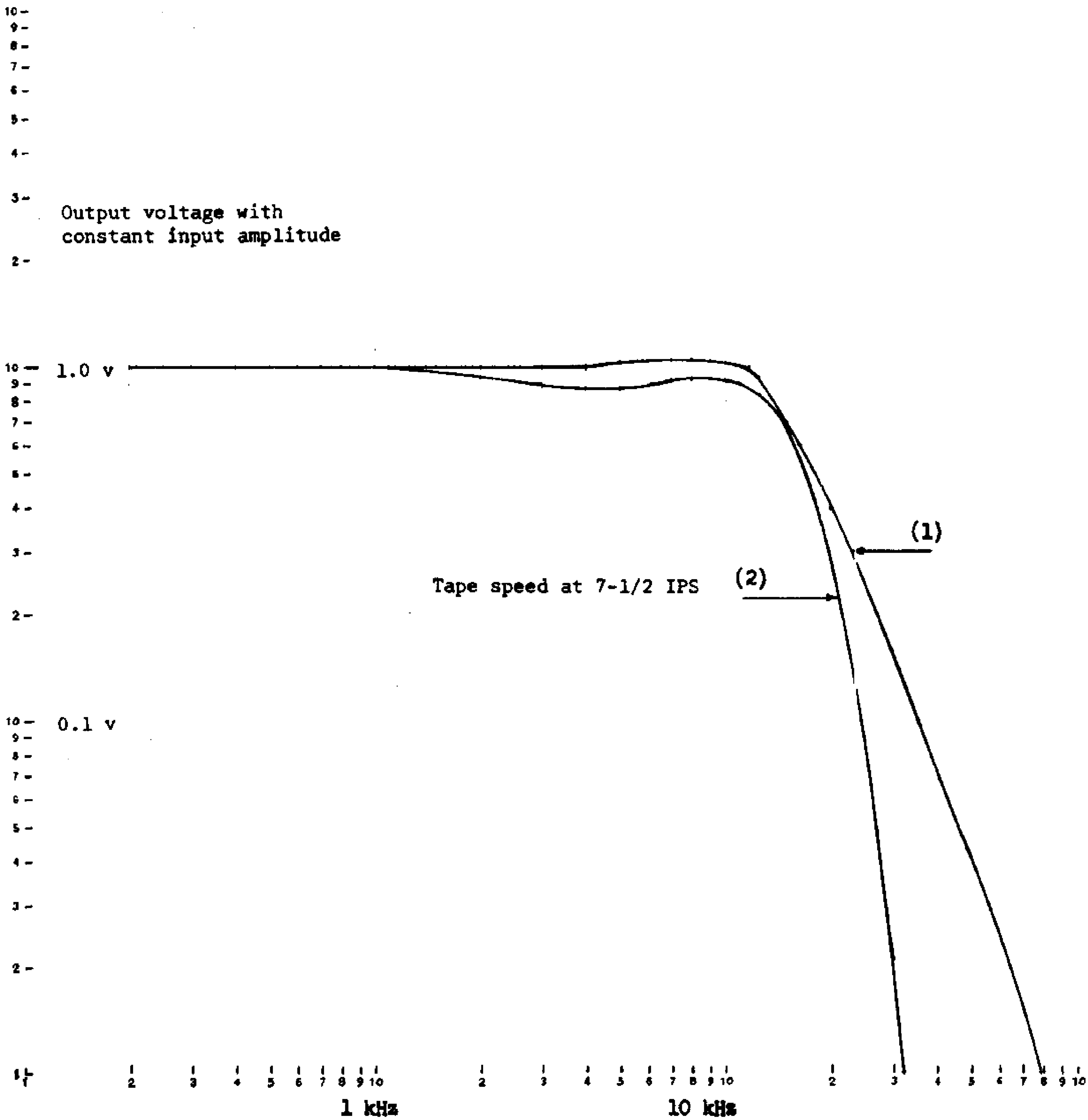

Fig. 4. Frequency response curves for the universal interface amplifier (1) and for the interface amplifier - tape recording system (2).

The input of the bipolar trigger circuit is protected by a pair of back-to-back, 3 v zener diodes that limit the maximum input voltage to a level that will not damage the transistors. Negative spikes or overshoots at the output of the circuit are eliminated by a diode. When the output is positive with respect to ground, the diode is reverse biased and will not conduct. When negative spikes occur, however, the diode will conduct and short them to ground.

Microphone Amplifier

The microphone amplifier is used to record voice markers on the magnetic tape and is connected to the synchronization pulse output jack. The amplifier is a high-gain Darlington type transistor biased to a point just below cutoff. When a microphone input is received at the base of the transistor, the positive half is amplified and appears at the synchronization pulse output jack. The negative portion of the voice signal reverse biases the base of the transistor and does not appear at the output. The quality of the microphone amplifier output is less than high fidelity but is easily understandable.

GENERAL COMMENTS

The maximum gain of the universal interface amplifier is unity. Amplifiers within the tape recording system must be used to set the proper record levels. The frequencies that can be converted by the amplifier are 38.5 kHz, 50 kHz, and 100 kHz in fixed steps. Frequencies from about 20 kHz to 500 kHz can be converted by adjustment of a variable resistor on position 5 of the frequency selector range switch. When the output from an echo sounder is within the frequency range of the tape recorder, the chopper can be disabled by the switching of the frequency selector switch to the off position.

The power requirements of the universal interface amplifier are 60 Hz, 117 VAC at about 2 w. The smallest DC to AC converters would be adequate if operation from a battery should be necessary. The output of the converter should be filtered when excessively large voltage spikes are present that could appear on the taped output of the amplifier.