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TECHNICAL NOTE

AN EMG PREAMPLIFIER SYSTEM FOR BIOMECHANICAL STUDIES*

A method for documenting hand and wrist positions using cinematography and electromyography was described by Armstrong, Chaffin and Foulke (1979). The purpose of this paper is to provide information for the construction of an inexpensive system for amplifying and rectifying surface EMG signals.

Simple modification of the Heath Schlumberger AC Voltmeter (Model SM-5238, Heath Schlumberger) adapts it for use as an electromyographic amplifier. The jack input was replaced with a five pin DIN connector providing input and power leads for an external preamplifier, as shown in Fig. 1.

A preamplifier for interfacing the electrode signal into the Heath Schlumberger AC Voltmeter was built using a low cost monolithic integrated circuit instrumentation amplifier (AD-521J Analog Devices, Box 280, Norwood, MA 02062, U.S.A.) as shown in Fig. 1.

The instrumentation amplifier is a high input impedance precision differential voltage gain device to maximize noise isolation. The differentially balanced inputs and a high common mode rejection ratio (up to 120 dB) make it possible to measure low level EMG signals (typically 3 μV to 1 mV r.m.s.) despite large common mode noise voltages at the electrode sites. Cables may also introduce extraneous noise inputs (i.e. cable capacitance noise) and a.c. coupling input networks affect both impedance and input balance conditions, particularly for higher frequency noise. To compensate for these conditions it is best to provide direct coupled amplification sited at the source of the signal being measured. These requirements are met through the use of the separate preamplifier and its small size allows it to be placed at the site of the EMG signal. Although the amplifier circuit is optimized for noise reduction, it has been the authors' experience that electrical ground loop interference (voltages exceeding common mode noise limits of differential amplifier) in some industrial environments prevents stable and reproducible measurements. For these applications a second stage isolation amplifier was constructed using a Burr Brown transformer coupled isolation amplifier (Module 3656, Burr-Brown, Box 11400 International Airport Industrial Park, Tucson, Arizona). Isolated power, generated in the circuits' miniature transformer is utilized to power the first stage preamplifier. This high frequency transformer coupling makes it necessary to shield the second state in a foil wrap to protect the preamplifier from electromagnetic interference.

The entire two stage system is packaged in an enclosure (Pomona Electronics No. 2417) or embedded in an epoxy resin or in a wax. The small dimensions of the system (1 × 2 × 1/2 in.) allow the device to be positioned comfortably at or near the electrode site. The system also retains the power output and signal input connections to the Heath Schlumberger Voltmeter as described previously and illustrated in Fig. 2.

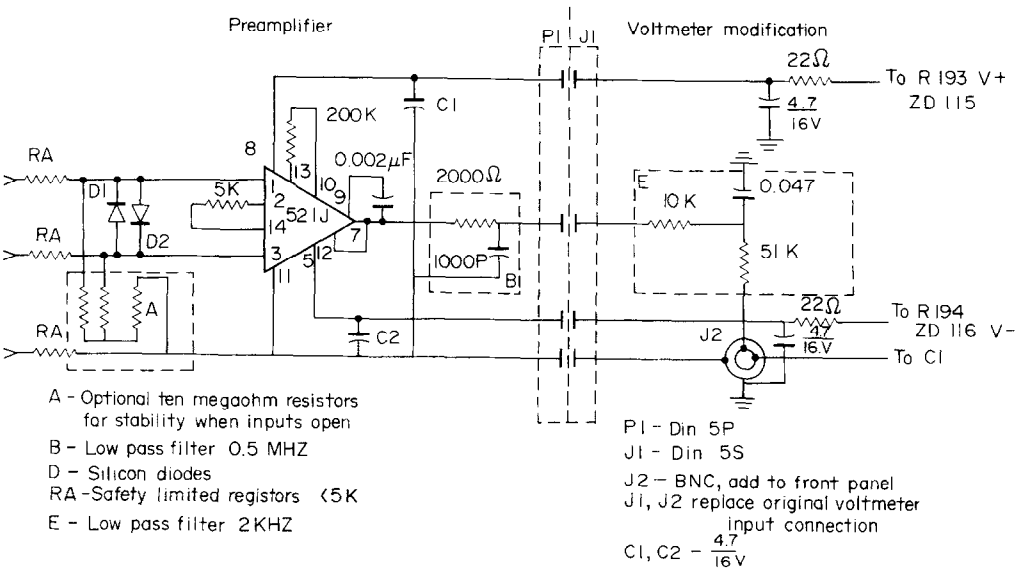

Fig. 1. High performance preamplifier with modification to use Heath Schlumberger SM-5238 a.c. voltmeter.

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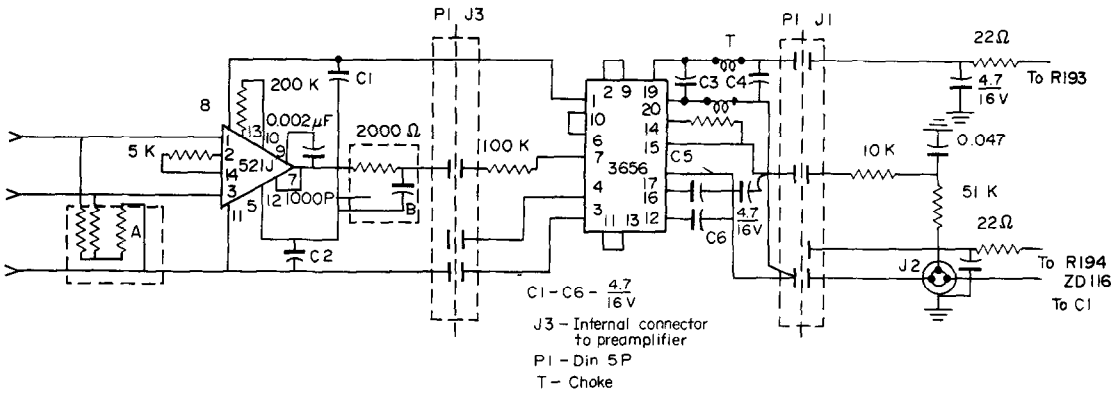

Fig. 2. Preamplifier with second stage isolation amplifier.

Subject protection is an inherent advantage of the isolated two stage preamplifier. When the analog devices instrumentation amplifier is used alone, subject protection is obtained with the 1/8 W resistors in series with the inputs as illustrated in Fig. 1. Fault currents arising by external electrical contact will be limited to let-go values for suitable values of RA shown in Fig. 1.

The preamplifier system can be used with standard gell electrodes as well as with pasteless dry electrodes, due to the high input impedance of the instrumentation amplifier (3×10^9 Ohms).

Features of this amplifier rectifier system include simultaneous a.c. output signals from preamplifier to an oscilloscope or recorder, r.m.s. voltage (d.c.) output to a strip chart recorder, variable gain control and dB-r.m.s. output permitting extended measurement range. This system has been used extensively under both laboratory and field conditions and has performed reliably.

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