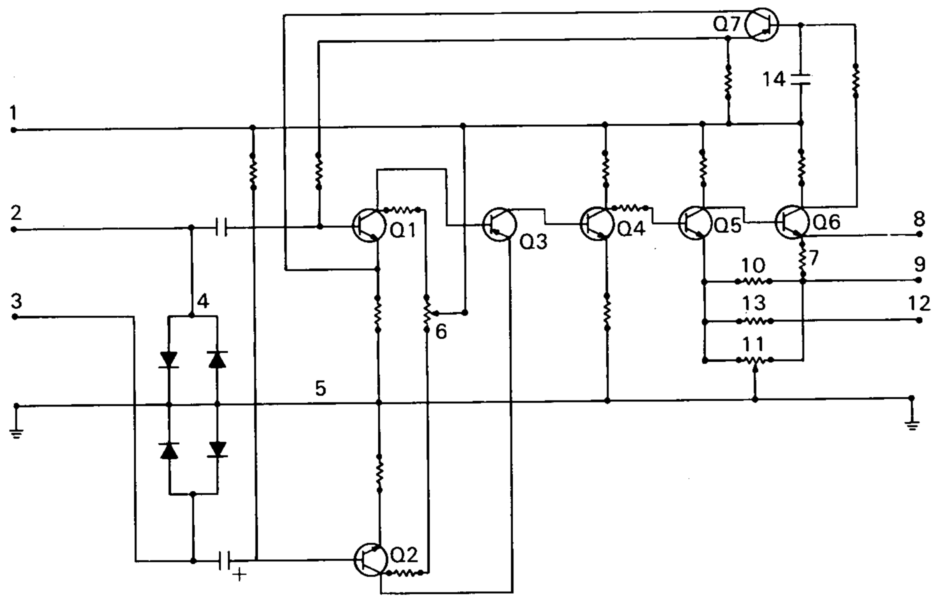
NASA TECH BRIEF

New Low-level A-C Amplifier Provides Adjustable Noise Cancellation and Automatic Temperature Compensation



The problem: In the field of medical instrumentation it is necessary to amplify low-level signals in the presence of relatively large variable noise signals. The size and complexity of the amplifier must be kept to a minimum.

The solution: The transistorized differential amplifier represented in the circuit diagram amplifies signals received from electrodes attached to the body of a person for the purpose of supplying an input to an electrocardiograph. The circuit provides a very-high-ratio common-mode rejection (approximately 10,000 to 1, referred to the input) and adjustable cancellation at the input for unbalanced noise signals. Cancellation for unbalanced noise is particularly important in biomedical applications, because the input terminals are often widely separated on the body where the noise levels may differ. It operates on a very-low-voltage supply to assure safety and includes a single active element across the input-output ends for automatic temperature compensation, which is particularly important where widely-varying ambient temperatures are encountered. An adjustable gain feature in the circuit does not require the use of matched input transistors. Operating on the 4-volt d-c supply, the amplifier requires 8 milliwatts of power to produce a 1-volt peak-to-peak output with a 3.6-millivolt input signal.

How it's done: The d-c power supply (not shown) is

(continued overleaf)

connected to input terminal 1. Input terminals 2 and 3 may be connected by balanced leads to separate electrodes attached to the body of a person. The two terminals (2 and 3) are coupled through separate capacitors to the bases of transistors Q1 and Q2, respectively. A diode network 4 is connected between each of the input terminals 2 and 3 and ground in order to prevent saturation of the input transistors Q1 and Q2 from overly large noise signals possibly appearing in the input of the circuit. These diodes form low-resistance paths to a common ground lead 5 for large input signals.

Like input signals impressed upon the transistors Q1 and Q2 will produce corresponding voltage variations at the collectors of these transistors, so that no voltage change occurs between the base and emitter of transistor Q3. This arrangement provides for conversion from a double-ended input to a single-ended output and at the same time provides for a common mode rejection; i.e., like voltage variations of the input terminals 2 and 3 with respect to ground do not produce signals passing to the output of the amplifier.

Adjustable noise cancellation is afforded by potentiometer 6 which has a resistor coupled to the collectors of the input transistors Q1 and Q2 and a variable contact connected to the power supply line of terminal 1. By changing the position of the variable contact, it is possible to increase the gain of one amplifier transistor while reducing the gain of the other and thus to balance the circuit when the noise levels at the two input terminals 2 and 3 are not equal. This arrangement allows the signal gain to be kept constant while providing for equalizing the noise gain.

Transistor Q3 in effect operates as a current source producing at its collector a current proportional to the signal from the bridge formed by the transistors Q1 and Q2. Following transistor Q3 is a direct-coupled amplifier including transistors Q4, Q5, and Q6.

An emitter-follower connection is employed to supply the output signal from the amplifier, and in this respect a resistor 7 is connected to the emitter of the last transistor Q6, with output terminals 8 and 9 being connected across this resistor. An additional resistor 10 may be connected in parallel with the resistor of the potentiometer 11, and an additional output terminal 12 may be coupled through a resistor 13 to the emitter of transistor Q5.

The circuitry for automatic temperature compensation includes a transistor Q7 having its base coupled through a resistor to the collector of the output transistor Q6. A capacitor 14 is connected from the base of the feedback transistor Q7 to the power supply for bypassing alternating current signals, so that only direct current signals are fed back to the input of the amplifier. Negative feedback is employed, so that the direct current signals returned to the input transistor Q1 are of opposite polarity to the direct current output variations of the amplifier, and consequently, serve to cancel these variations. In this way compensation is provided to prevent direct-current drift of the circuit with variations in temperature of the circuit components.

Notes:

1. A unit constructed with particular circuit-component values was operational in approximately 20 seconds and was 3db down in gain at 0.3 cps and at 70,000 cps. Its low frequency response is determined by the temperature-compensating network.
2. This amplifier should prove useful in many applications, including hi-fi equipment.

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