Circle 523

Bio-Potential-To-Frequency Converter/Modulator

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The modulator circuit presented here was designed to provide a simple and inexpensive portable means for recording bio-electric (typically electrocardiogram) signals. Such low-level (1 mV) bio-electric signals are characterized by low-frequency bandwidths (approximately 1 Hz to 100 Hz). Thus, they're amenable to long-term recording on inexpensive audio cassette recorders, given a satisfactory means of extending the low-frequency capability of the magnetic media to near dc. An extra efficient and flexible variation on this theme results when the cassette recorder is mechanically modified to slow the linear tape transport speed by a large factor (sometimes as much as 10 to 1).

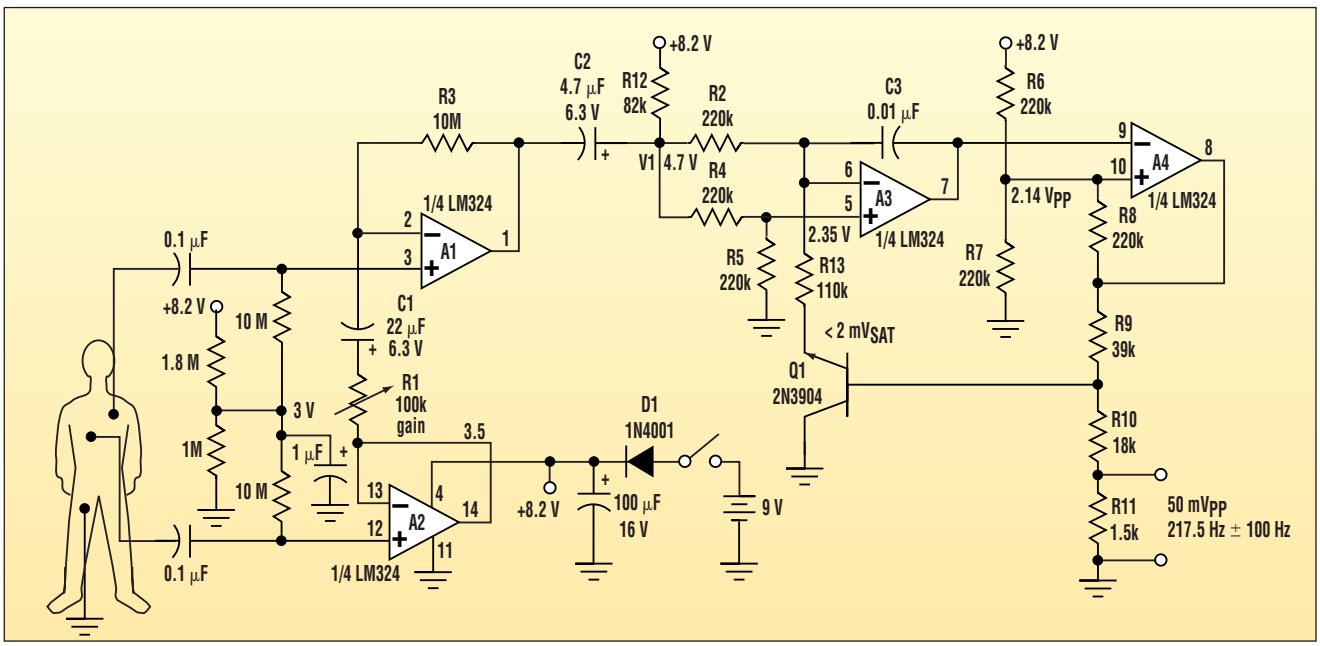
Such a modification is compatible with the narrow bandwidths characteristic of bio-potential data. It supports various applications, such as providing up to 10 hours of continuous (e.g., overnight) monitoring of cardiac activity on standard format audio cassettes. Playback of recorded data is typically accomplished via an unmodified cassette deck (thus permitting accelerated recovery of lengthy recording) interfaced to any of a number of commercial PC-compatible counter-timer boards.

The modulator consists of the differential high-gain electrode amplifier, which comprises op amps A1 and A2 along with associated discrete components. The electrode gain is adjustable via variable resistance R1 over a range of 100 to approximately 10,000. This will accommodate realistic bio-electric potentials, boosting them to levels adequate for control of the VFC portion of the modulator.

The modulator VFC consists of reversible-polarity integrator A3 followed by a bi-level comparator A4. When operating, A3 ramps at a rate given by the expression: ±227*V1 (V/sec), where the direction (±) of the ramp is determined by the state (ON/OFF) of Q1. Regenerative comparator A4 controls Q1's state. The positive feedback and bias network (R6, R7, R8, and R9) surrounding A4 provides about 2.1 V of hysteresis and a consequent 2.1-V p-p triangular waveform at A3's output. Assuming a nominal zero-signal center value for V1 of 4 V, this yields a 2.1/(4*227) = 2.3-ms half-cycle period and a center frequency (F_O) of 218 Hz.

Amplified bio-electric signals of up to 2 V p-p are added to F_O at V1 to produce an fm deviation of 200 Hz p-p. The frequency-modulated square-wave output from A4 is attenuated to a level suitable for input to the remote microphone input of typical cassette recorders (about 50 mV p-p).

Power for proper modulator operation is supplied directly from a 9-V battery. Absence of explicit voltage regulation is no obstacle to proper circuit function due to the imprecise nature of bio-potential signals, as well as the tolerant input requirements of recorder microphone inputs.



This electrocardiogram circuit can provide up to 10 hours of continuous cardiac activity monitoring on a standard audio cassette.