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NASA TECH BRIEF

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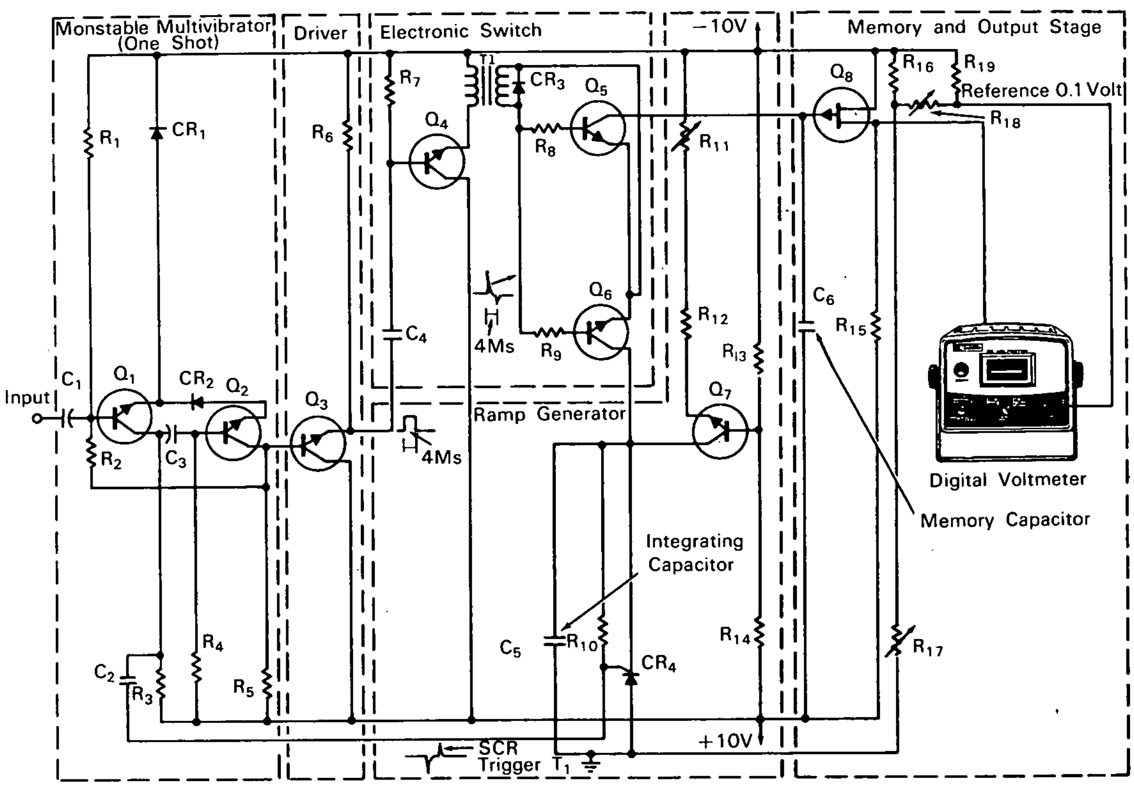
Digital-Output Cardiotachometer Measures Rapid Changes in Heartbeat Rate



The problem: Analog cardiotachometers are inherently nonlinear and do not respond with sufficient speed to indicate rapid changes in heartbeat rate. Those digital cardiotachometers that are capable of measuring heartbeat rate on a beat-by-beat basis are generally complex and costly.

The solution: A cardiotachometer circuit that produces an output voltage proportional to the heartbeat rate on a beat-by-beat basis. Direct readings in beats per minute are obtained on a linear scale of a digital voltmeter. This circuit is designed to be used with an auxiliary circuit (described in NASA Tech Brief B65-10142, May 1965) that converts a subject's electrocardiogram into square-wave pulses at a frequency proportional to the heartbeat rate.

(continued overleaf)

How it's done: The square-wave pulses from the auxiliary circuit are applied as the input to the cardiotachometer. These pulses trigger the monostable multivibrator (Q_1-Q_2) which converts them into short-duration (4-millisecond) square-wave pulses. The narrow pulses pass through the driver stage, Q_3, and are differentiated in the Q_4 emitter and T_1 transformer circuit. The positive-going portion of the differentiated square wave appearing on the secondary of T_1 passes to the base elements of the normally cut off switching transistors Q_5 and Q_6. On receipt of a positive pulse, these transistors are turned on to transfer the voltage developed on integrating capacitor C_5 to the memory capacitor C_6. A few milliseconds later, the silicon controlled rectifier (SCR), CR_4, is triggered and shorts out the charge on C_5. The SCR then returns to the quiescent state and C_5 becomes ready to start another cycle when the next positive pulse appears.

Capacitor C_5 is sampled and then shorted out each time a 4-millisecond pulse is generated. The time between pulses is relatively long (0.3 to 3 seconds). During this interval, C_5 will continue to charge at a linear rate through Q_7 toward -10 volts, until the next heart beat (4-millisecond pulse) activates the switching transistors to transfer the charge from C_5 to C_6. Transistor Q_7 provides the constant-current source necessary for a linear charge rate, so that the amplitude of the ramp voltage on C_5 is a function of the time between heart beats.

The charge on C_6 biases the field effect transistor, Q_8, to control the current through R_{15}. Since a field effect transistor is a high-impedance device, the charge on C_6 will not leak off between pulses. The voltage across R_{15} is therefore a function of this charge. This output voltage is applied to a commercial digital voltmeter in a unique manner. Normally the voltage would be applied to the voltmeter's input terminals. Instead, the output voltage is applied to the voltage reference circuit inside the meter case and a 0.1-volt reference is applied to the input terminals. The digital voltmeter is thus connected as an electronic divider or ratiometer to provide readings of the heartbeat rate directly in beats per minute.

Notes:

1. An analog cardiotachometer is described in NASA Tech Brief B65-10010, January 1965. Inquiries may also be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10143

Patent status: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

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