

# Inexpensive EKG Gate for Computer-Processed Cardiac Motion Study

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***A simple EKG gating device was constructed from two commercially available integrated circuits. It can be directly interfaced to a computer for motion studies of the heart.***

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Recently computer-processed cine-radionuclide-angiography (CRA) of the heart has begun to be more widely used for the study of cardiovascular diseases (1). Instead of gating the end-diastole and end-systole images on film, the scintillation events throughout the heart cycle are sorted by the computer so that a series of 10-28 frames representing the entire heart cycle is obtained. By rapidly projecting these frames on a viewing screen, the motion of the heart can be visualized in a movie-like manner, as in contrast angiography (2).

The CRA technique requires an EKG gating device to indicate the beginning of the heart cycle. Gates for this purpose are available commercially but they are expensive. An inexpensive EKG gating device has been built and tested in our department using two commonly available integrated circuits and a single 5-volt power supply.

The EKG gate consists of a voltage comparator\* and a current-differentiating amplifier† connected with several resistors as illustrated in Fig. 1.

The signal from a standard EKG machine is connected to the positive input of the LM311. The patient's EKG

electrodes should be placed on the chest such that the R waves are deflected upward, giving a positive voltage for comparison. A reference voltage of approximately 0.3-0.4 volts is provided by resistors R1 and R2. By use of a variable resistor (trim pot) for R2, the reference voltage can be adjusted to match the output voltage from the EKG machine. When the QRS complex of the incoming EKG signal exceeds the reference voltage, a 5-volt pulse is put out by the comparator. This signal is fed into the LM3900, a current-differentiating amplifier that provides the current required to drive the signal to the computer interface by way of co-axial cable.

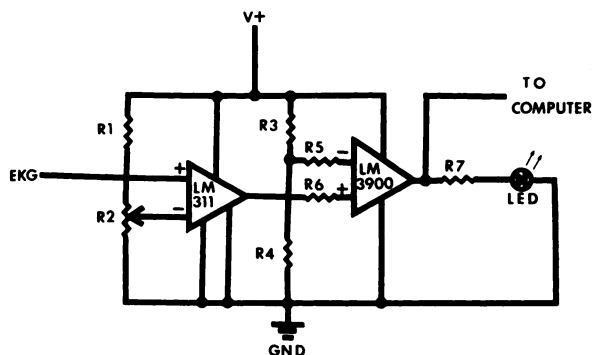
The computer interface varies slightly from system to system, but in general it recognizes the rising edge of the 5-volt pulse as the beginning of the heart cycle. Our gate has been successfully interfaced to the Medical Data Systems computer (Ann Arbor, Michigan), as well as to the General Electric Medstore (Milwaukee, Wisconsin).

In order to monitor the gating process visually, a light-emitting diode (LED) is provided at the output of the LM3900, so that a flash occurs during each R wave. By checking the light monitor, the technologist is able to spot irregular heart beats, artefacts from poor electrode connections, etc.

## DISCUSSION

Various ways of predicting the end of cardiac diastole have been attempted before. Methods that employ the PR interval predicted by 95% delay of the preceding R-R duration are less accurate than the method of end-diastolic timing using triggering by the R wave with zero delay (3). The CRA technique obviates inaccuracy involved in the prediction of end-systole because multiple frames of the entire heart cycle are generated by the computer. By visually observing the contraction of the left ventricle, as in contrast angiography, the end-systole is located at the full contraction of the left ventricle.

Our EKG gating device locates the QR interval by direct



**FIG. 1.** V+ = 5-volt dc power supply; GND = ground connection; LED = light-emitting diode; LM311 = comparator integrated circuit (National Semiconductors); LM3900 = current-differentiating amplifier integrated circuit (National Semiconductors); Resistors (in ohms, ¼-watt); R 1 = 100 K; R 2 = 25 K (trim pot); R 3 = 5.1 K; R 4 = 5.1 K; R 5 = 22 K; R 6 = 22 K; R 7 = 150.

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comparison with a reference voltage. The comparator-driven circuit is not novel but is reliable and easy to build, and the components are readily available at less than \$10. The simple gate has satisfactory noise immunity and no heart-rate limitations, but it does not provide corrections for cardiac arrhythmias. Irregular heart beats can, however, be excluded by the processing computer program during framing of the heart cycles. The compactness of the gating device facilitates its direct mounting on an EKG machine, making it ideal for portable studies to be performed in coronary care units away from the nuclear medicine laboratory.

## FOOTNOTES

\* LM311 or LM111 National Semiconductors, Santa Clara, Calif.

† LM3900 National Semiconductors,, Santa Clara, Calif.

## ACKNOWLEDGMENTS

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