Behavior Research Methods, Instruments, & Computers
1985, 17 (3), 385-387

INSTRUMENTATION & TECHNIQUES

An optoelectronic motion-sensing eye blink detector

SPERO A. METALIS
Loyola University of Chicago, Chicago, Illinois

and

FRANK DRUSS
University of Chicago, Chicago, Illinois

A noninvasive eye blink detector can be built at low cost from a Sprague optoelectronic motion detection module, a voltage level detector, and a tone burst generator. The blink detector triggers reliably when used to detect motion appearing on the video monitor of a videotape recorder.

The eye blink is a widely used dependent variable in studies using the respondent conditioning paradigm (Clarkson & Berg, 1984), as well as in studies of emotion, vigilance, and cognition (Holland & Tarlow, 1975; Kanfer, 1960; Stern, Walrath, & Goldstein, 1984). Blinks have been reliably measured by any one of several transducers: a strain gauge mechanically attached to the eyelid, a polygraph set to record electrooculograms, video tape recordings, and various photodetection devices. Each method has its strengths and weaknesses, and these must be assessed carefully before use.

In this article, we describe an eye blink detector with two desirable features: (1) It is noninvasive and avoids the physical discomfort which may occur with methods that require attachments to the eyelid or face of the subject, and (2) it can be constructed at a cost of less than $40. Since the detector has only three integrated circuits, it is relatively easy to assemble. It cannot, however, in its present configuration yield the millisecond time resolution required by some eye blink research paradigms (Stern, Walrath, & Goldstein, 1984).

EYE BLINK DETECTOR

The device consists of an optoelectronic module, a connecting cable, and an electronic interface unit. The optoelectronic module is the Sprague Opto-Linear Motion Detector, consisting of a Sprague's ULN-2232A integrated circuit, a small printed circuit board, and four capacitors. The module is the basis for many motion-detecting intrusion alarms (Gontowski, 1980). Although the device is no longer available from Sprague, it is sold for approximately $4.00 by several surplus firms.[1]

This project was supported by a grant from the Spencer Foundation.
Please address all reprint requests to: S. A. Metalis, Department of Psychology, Loyola University of Chicago, 6525 N. Sheridan DH-616, Chicago, IL 60626.

The optoelectronic module is triggered by a change in light of as little as 5%. It is small enough to be attached to the visor of a baseball cap (a convenient head mount scheme) and can be aimed easily at the white of the eye. As such, it functions as an on-line blink detector. It can also be used off-line. If a videotape recording of a close-up image of the eye is made, then during playback the device can be aimed at the videotape monitor screen. Each occurrence of an eye blink causes it to trigger.

The interface unit, which must be built from separate components, consists of an LM 324 quad op-amp chip and a 556 dual timer chip, both widely available from hobby electronics suppliers.

The alarm function of the Sprague unit is bypassed, and a pulse output (which occurs with each blink) is sent to the interface unit. This pulse is detected by the level detector in the interface unit, which then triggers a tone burst generator. The tone burst can be recorded on audio tape.

The Sprague unit includes a built-in filter to make the module insensitive to 120 Hz fluorescent light flicker. To extend the utility of the blink detector, an additional filter is included in the interface, between the motion detector module and the level detector. This filter makes the device insensitive to the 60 Hz video-blanking trace of the monitor screen, and avoids the false triggering that would otherwise occur when the device is pointed at a screen.

The tone burst generator consists of a one-shot with a differentiated input, and an audio frequency oscillator. Each time a blink is detected, it produces a 30 msec tone of 1000 Hz.

Figure 1 illustrates the changes that need to be made to the Sprague unit. Figure 2 shows a circuit diagram for the interface between the Sprague module and a tape recorder. A TTL-compatible one-shot output is included to enable the interface unit to automatically advance an event counter. This allows on-line determination of number of eye blinks per experimental manipulation. The list of parts is shown in Table 1.

Table 1
Parts List

Resistors (all ½W):
R1-R4, R11 = 10M
R5, R6 = 100K
R7 = 56K
R8 = 25K potentiometer
R9 = 3.3K
R10, R12 = 10K
R13 = 270K
R14 = 12K
R15 = 1.2K
R16 = 220 Ω (or 1K potentiometer)
R17-R20 = 47 Ω
Capacitors:
C1, C2 = 0.01 μF ± 10% (metalized polyester film)
C3, C5 = 0.01 μF ceramic disc
C7 = 4.7 μF 15 V electrolytic
C8 = 1.0 μF 15 V electrolytic
Other Parts:
Sprague Opto-Linear Motion Detector
LM 324 Quad Op Amp
Type 556 Dual Timer
D1 = Zener Diode 1 watt ± 5% 4.3 V (e.g., GEZD—4.3, or ECG5068A, or SK3332)

The mounting and placement of the Sprague module and the careful adjustment of the level control are critical for good results. For instance, if the Sprague module is mounted slightly above eye level and is aimed down at the subject's eye, false indication of a blink is likely to occur each time the subject looks down. This problem can be eliminated largely by mounting the Sprague module a little below eye level, so that it is aimed up at the eye. The tendency to register misses or false alarms can be eliminated by careful readjustment of the level control.

Construction Notes

On the Sprague unit, the 4.7-uhf 35-V orange-dipped tantalum capacitor is replaced by a 0.001-uhf ceramic capacitor, to reduce the time-out interval from about 4 sec to 8 msec, so the detector device can respond several times per second. The output is taken from Pin 11 to bypass the alarm feature and obtain a positive pulse output (approximately .75 V) each time a light change is detected. This is done with a jumper from Pad A. Pins 13 and 14 are connected to V+, to enable the automatic reset feature. This is done with a jumper from Pad B. An opaque hood is cemented to the Sprague transparent plastic IC to shield the lens from light changes more than 30 deg off the central axis and prevent extraneous illumination changes from producing false alarms. A black plastic sleeve from a mini-plug or mini-jack works well. Since the IC is made of transparent plastic, some black tape on the edges of the IC will also be needed.

If the one-shot is used to drive a TTL counter, a regulated 5-V TTL power supply must be used. Otherwise, a 6-V lantern battery may be used as a power supply. A resistance and a 4.3-V Zener diode are included to convert the 5-6 V suitable for the LM 324 and 555 to a lower voltage required by the Sprague module. The resistance needs to be 47 Ω 1 W, which can be obtained from a series-parallel network of 47-Ω ½-W resistors, as shown in Figure 2.

For on-line recording, it is useful to attach a small 6-V incandescent lamp along the central axis of the plastic sleeve, pointing at the eye. This lamp insures that the detector has a constant light source.

The output of the tone burst generator will operate an earphone or small speaker, but is too large for some audio recorder inputs. To reduce the signal to a more appropriate level for recording, a Radio Shack attenuating plug (RS 274-300) may be used.

ACCURACY TEST

To test the accuracy of the blink detector, five subjects, college students of both sexes, were monitored simultaneously by the blink detector and a videotape recorder with camera. The Sprague module was mounted on the visor of a baseball cap snugly fitted to each subject's head.

Three on-line tests were made to compare the blinks seen on the video channel with the tone bursts generated by the blink detector and recorded on the audio channel. In one test, the subjects were asked to blink once a second for 10 sec. In another, the subjects read news magazine articles aloud. In the third test, the subjects listened to the articles being read. These same three procedures were then used for the off-line tests, comparing the video channel record of blinks with the tone bursts generated by the blink detector aimed at the videotape monitor screen during playback.

The off-line records yielded 100% fidelity. The on-line records for voluntary blinking and for listening to text also yielded 100% fidelity. The on-line record for reading aloud initially yielded occasional misses and false alarms, which seemed to be caused by subject head movement or eye movement. But in each case, raising or lowering the sensitivity by adjusting the level control, or repositioning the cap with the Sprague module on the subject's head eliminated the problem.

REFERENCES

CLARKSON, M. G., & BERG, W. K. (1984). Bioelectric and potentiometric measures of eyeblink amplitude in reflex modification paradigms. *Psychophysiology*, **21**, 237-241.

GONTOWSKI, W. (1980). Build a motion detector alarm. *Popular Electronics*, **17**, 61-70.

HOLLAND, M. K., & TARLOW, G. (1975). Blinking and thinking. *Perceptual and Motor Skills*, **41**, 403-406.

KANFER, F. H. (1960). Verbal rate, eyeblink and content in structured psychiatric interviews. *Journal of Abnormal and Social Psychology*, **61**, 341-347.

STERN, J. A., WALRATH, L. C., & GOLDSTEIN, R. (1984). The endogenous eyeblink. *Psychophysiology*, **21**, 22-33.

NOTES

1. The Sprague motion detector module is available from Electronic Supermarket, P. O. Box 619, Lynnfield, MA, 01940, (617) 532-2323, or from BNF Enterprises, P. O. Box 3357, Peabody, MA, 01961, (617) 531-5774.

(Manuscript received July 25, 1984;
revision accepted for publication March 22, 1985.)

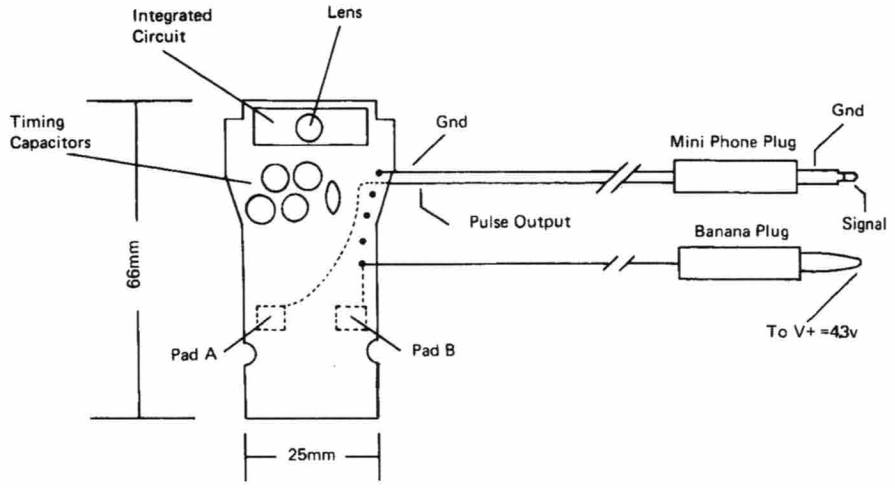

Figure 1. Construction diagram for modifying Sprague Opto-Linear Motion Detector.

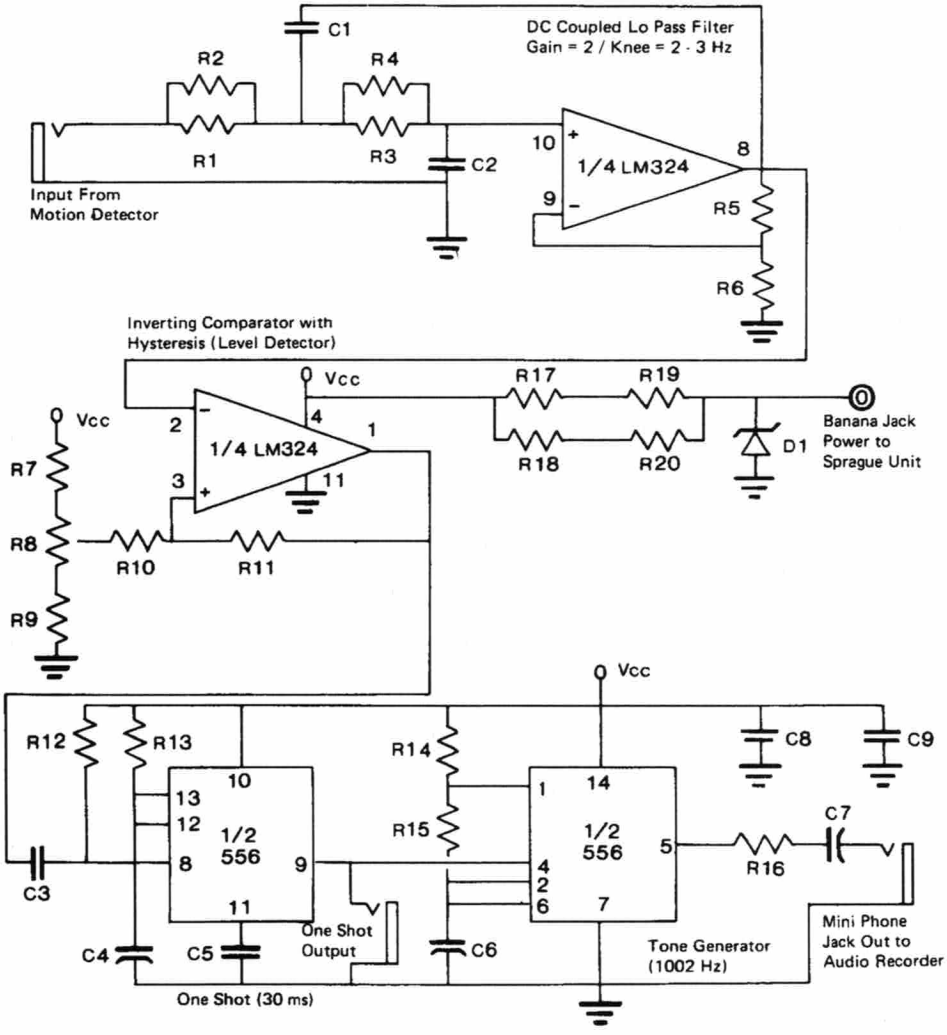

Figure 2. Schematic of Sprague unit/audio recorder interface circuit.