Behavior Research Methods, Instruments, & Computers
1984, 16 (6), 538-539

Simple circuit for grating contrast adjustment

RHEA T. ESKEW, JR.
Georgia Institute of Technology, Atlanta, Georgia

MICHAEL PACE
Digital Controls, Inc., Norcross, Georgia

and

EDWARD J. RINALDUCCI
Georgia Institute of Technology, Atlanta, Georgia

A multiplication circuit that can facilitate generation of variable-contrast luminance gratings via a microcomputer is described. The circuit is inexpensive and easy to build.

The use of sinusoidal luminance gratings has been widespread in studies of visual perception and physiology in recent years. A number of techniques have been devised to generate these stimuli on oscilloscopes (e.g., Campbell & Green, 1965; Fritsch & Keck, 1978; Shapley & Rossetto, 1976). This paper describes a simple circuit that can facilitate generation of variable-contrast gratings by microcomputer.

Fritsch and Keck (1978) described a very useful means of creating sinusoidal luminance gratings with a 6502-based microcomputer, although the technique is easily adaptable to any microprocessor. In this scheme, a table of sinusoidal values of a given modulation or contrast and frequency is first generated and saved in the computer's memory. A sweep is initiated on the oscilloscope via a signal from a digital output port on the computer. The precalculated sinusoidal values are then output to the z-axis input of the oscilloscopes via a digital-to-analog (D/A) converter, while a separate function generator supplies a high-frequency sawtooth or triangle wave to the y-axis input of the oscilloscope. This sequence is repeated rapidly. Provided that the sweep rate of the oscilloscope is adjusted to match the rate at which the computer outputs the sinusoidal values, the result will be a stable sinusoidal grating on the face of the oscilloscope.

This method of grating generation is limited to vertical gratings, as is the variation of it described here, but is otherwise quite flexible: Any waveform may be used, so that the grating may be square wave, triangle wave, or a sum of two or more sinusoids. The only fundamental limitation is that imposed by the resolution of the D/A converter, which in turn limits the amplitude resolution on the z-axis. However, a major disadvantage is that the contrast of the grating must be precalculated. This means that continuous adjustment of contrast, for instance, is difficult to achieve without either using up large blocks of memory by storing sinusoidal tables of various contrasts, or interrupting the display.

If the D/A converter providing the sinusoidally varying voltage can provide a bipolar signal, it may be operated such that the mean level of the sinusoid is at 0 V. Then another D/A converter may be used to provide a voltage that varies with the desired contrast, and the two signals multiplied by an external multiplication circuit. However, many of the more commonly used D/A converters can provide only unipolar signals, and multiplication by a contrast signal would shift the mean level of the sinusoid up and down, as well as change its amplitude. More importantly, many of the oscilloscopes that are commonly used in studies of visual perception (e.g., the Tektronix 608) can accept only a unipolar signal to the z-axis, and thus shifting the sinusoidal signal down to a zero offset would not alone solve the problem.

Figure 1 shows a schematic of a simple circuit that will perform a multiplication after producing a zero-offset sinusoid and then add an offset so that the signal is once more unipolar. The offsets are independently adjustable, and thus the circuit is quite flexible. The components of this circuit are two operational amplifiers (the two halves of the 4558 chip), a transconductance amplifier (the XR13600), four trim pots (R1-R4), and a number of resistors. Two power supplies, one +12 and one −9 V, are required.

The output of the circuit is of the form

$$V_{out} = k_2V_2[(k_3V_1) - k_4] + k_1,$$

where V_1 and V_2 are the two input voltages from the D/A converters (0-5 V dc), and the ks are adjusted using the resistors with the corresponding subscript. The transconductance amplifier uses the signal provided at its pin 1 by the lower operational amplifier as a multiplying sig-

The authors express their appreciation to John S. Houston, Jeffrey B. Mulligan, and an anonymous reviewer for helpful comments on a draft of this paper. The current address of Rhea Eskew is Center for Human Information Processing, C-009, University of California at San Diego, La Jolla, CA 92093.

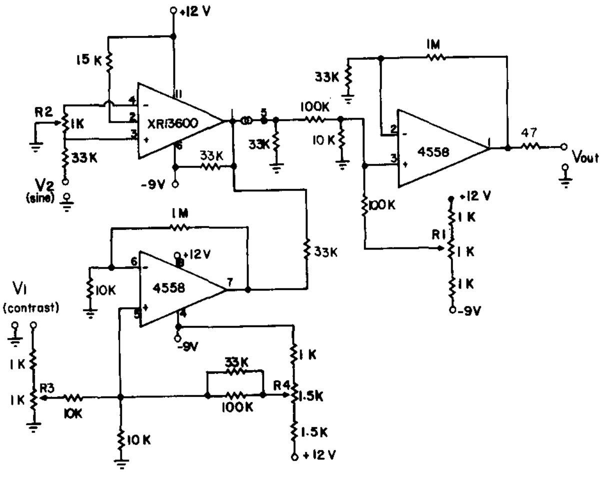

Figure 1. Schematic of the contrast-adjusting circuit. The components are two integrated circuits (the 4558 and the XR13600, or equivalents), four trim potentiometers (R_1-R_4), and a number of resistors. Input voltages should be in the range 0 to 5 V dc, with adjustable output of 0 to 12 V dc. The XR13600 is manufactured by Exar Integrated Systems, Inc., of Sunnyvale, California; the 4558 is made by Motorola Semiconductor Products, Inc., of Tempe, Arizona.

nal for the sinusoidal input, in a two-quadrant multiplication operation.

In order to create a sinusoidal luminance grating, make V_1 proportional to the desired contrast, make V_2 vary sinusoidally with the desired frequency, and adjust R_4 such that when V_2 is at its mean value, V_{out} will equal the desired offset voltage, provided via an adjustment of R_1.

This circuit can be built for only a few dollars, excluding the power supplies. Its operation is not significantly affected by noise in this application, its output is extremely linear, and the four trim-pot adjustments provide a great deal of flexibility of application. Any microcomputer, in conjunction with two D/A converters and at least one digital output port, may be used. Controlling two gratings independently does not require four D/A converters. Instead, one may simply take V_{out} from the circuit and apply it to the z-axes of two oscilloscopes simultaneously. By sweeping the oscilloscopes alternately, using two different pins of the digital port, and alternating the functions applied to the two D/A converters, different patterns may be created on the two screens.

In summary, the circuit described here, in conjunction with the appropriate software, allows a microcomputer to generate vertical periodic luminance gratings, the contrast of which can be continuously varied without interrupting the display. The circuit is flexible, inexpensive, and easy to build.

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(Manuscript received October 31, 1984;
revision accepted for publication January 11, 1985.)