THE ELECTRONICS SCIENTIST

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By Forrest M. Mims, III

Use of Ultrasonic Sound

SEVERAL years ago I walked blindfolded through the grounds of the Arkansas Enterprises for the Blind wearing a unique pair of spectacles. On the bridge of the spectacles were three ultrasonic transducers connected by cable to a pocket-sized electronics package.

As I scanned my surroundings, a sequence of strange and exotic swept-frequency tone bursts were fed into my ears by plastic tubes. Depending upon the target's distance and surface texture, the sounds ranged from drzzz . . . drzzz . . .drzzz to whoosh . . .whoosh . . .whoosh.

Although not nearly a substitute for eyesight, the spectacles highlight the application of ultrasonics in our everyday lives. There are many other interesting applications as well. One of the most recent is the ultrasonic ranging system developed by Polaroid for its SX-70 camera. We'll be discussing the design and operation of Polaroid's system here, but first let's find out more about ultrasonic sound.

Sound waves that have frequencies below and above the limits of normal human hearing are termed, respectively, *infrasonic* and *ultrasonic* sound. Infrasonic sound has a frequency less than a few hertz. It is generated by earthquakes, machinery, and moving air. Ultrasonic sound has a frequency greater than 20 kHz. It is generated by mechanical and electronic sources, jingling keys, rustling leaves, and animals such as bats.

Applications for low-intensity ultrasonic sound include measurement of mechanical stress, flaw detection, and non-optical imaging devices such as those used to view the fetus of a pregnant woman. High-intensity ultrasonic sound is used for soldering, surgery, mixing liquids such as water and oil, and forcing dirt and oil from objects immersed in an ultrasonically agitated liquid.

Though all these applications are important, none has generated as much interest as two of the very first applications for ultrasonic sound: distance measuring and object detection. As early as 1918, scientists had developed practical systems for detecting submarines by reflected waves of ultrasonic sound. In World War II, this technology became widely known as *sonar*, an acronym for *so*und *n*avigation *a*nd *r*anging. Today military applications for sonar range from detection of submarines over a range of 10 km or more, mine detection, and guidance and control of various homing weapons.

The best-known civilian applications for sonar include the detection of fish and depth sounders. Detection applications in which the sound waves are propagated through air include ultrasonic intrusion alarms and, as described, travel aids for use by the blind and automatic focusing systems for cameras.

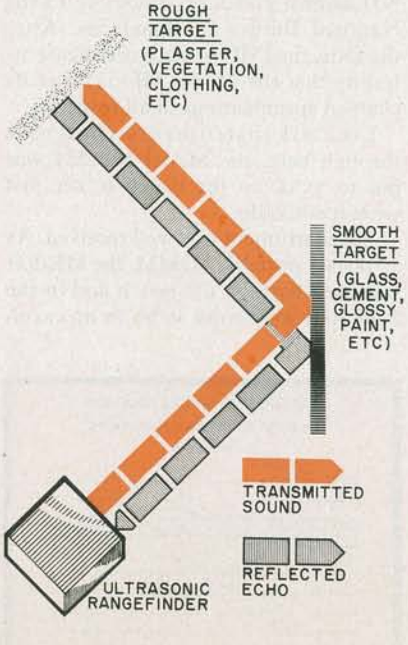

Fig. 1. A smooth target can cause false distance readings.

Polaroid's Ranging System. When Polaroid introduced its automatically focused SX-70 instant picture camera, more interest was expressed in the product's ultrasonic rangefinding system than in the camera itself. A few years ago Polaroid responded to this interest by introducing its Ultrasonic Ranging System Designer's Kit. The kit contains two preassembled circuit boards, two instrument-grade electrostatic transducers, two 6-V Polapulse© batteries, a battery holder, and an instruction manual. The kit is available for $150 from Polaroid Corporation (Battery Division, 784 Memorial Drive, Cambridge, MA 02139).

This remarkable kit requires only that the battery holder leads be clipped or soldered to one of the two circuit boards. It can then be used as an ultrasonic rangefinder, complete with a 3-digit LED display. It can detect and indicate the distance to objects within a range of 0.9′ to 35.2′. It has a resolution of ±0.12″ at distances out to 10′ and ±1% over the entire detection range.

Since I've had considerable experience designing and testing infrared travel aids for the blind, I was particularly interested in experimenting with Polaroid's ultrasonic ranging system. The unit is much more sensitive than I had expected. For example, it will reliably detect a 1″ diameter unfinished wood pole at 18′; it will detect a 9″ diameter utility pole at 28′; and it will detect power lines 19′ overhead.

The only major drawback of the system is its inability to reliably detect targets having a surface that is smooth with respect to the wavelength of the ultrasonic sound. Borrowing from optical terminology, such targets can be termed *specular reflectors.* If the surface texture of the target is rough with respect to the wavelength of the ultrasonic waves, the target can be termed a *diffuse reflector.*

Flat, specular targets whose surface is normal (perpendicular) to the oncoming sound waves are readily detected. When the target is off-axis to the beam of sound, however, the ultrasonic waves are reflected at an angle away from the source.

This can give rise to anomalous readings if the diverted off-axis beam eventually strikes a second surface having acceptable target characteristics. The sound will reflect back to the intended target and from there to the ranging system. The range measurement displayed by the readout, will, therefore, be the two-path distance to the second, unintended target. The intended target will be ignored. This phenomenon is illustrated in Fig. 1.

Infrared rangefinders that use LEDs and diode lasers exhibit this same problem when used to detect specular reflectors such as glass, polished marble, and automobiles with a high-gloss surface. Therefore, I was not surprised when the ultrasonic system could not detect these targets at an off-axis angle.

What was astonishing was the wide range of targets having relatively rough surfaces which, in fact, appear specular to an ultrasonic beam. Typical targets that are difficult or impossible to detect at other than the normal angle include smooth cement walls and driveways, plywood, painted surfaces, automobiles, flat metal plates, etc.

Fortunately, most targets include diffusely reflecting features that make detection possible even at off-axis angles. For example, the curved surfaces of most cars usually cause some of the ultrasonic beam to be reflected back toward the source. Overall, there are more diffusely reflecting targets (fabric, vegetation, shingles, people, posts, carpets, etc.) than specular targets. Nevertheless, it's prudent to be aware of the difficulties posed by specular reflectors when using an ultrasonic ranging system, particularly since Polaroid's otherwise excellent rangefinder manual fails to discuss the subject.

The Transducer. The key component of the Polaroid system is an instrument-grade electrostatic transducer that doubles as both an ultrasonic speaker and microphone. A foil diaphragm is stretched tightly over the concentrically grooved metallic backplate to form a capacitor. In receive mode, capacitance of the transducer is altered by incoming sound waves. In transmit mode, the electrostatic force of a charge placed across the capacitor causes the foil to move.

The transducer emits a relatively narrow sound cone (nominally 20° in divergence at the −20-dB points). The best operating frequency for the unit falls between 50 and 60 kHz. These parameters are clearly summarized in the plots, adapted from Polaroid's manual, which are shown in Fig. 2.

The Ultrasonic Circuit Board. The transducer is connected directly to the Ultrasonic Circuit Board, a slightly modified version of the board found in the SX-70 camera. Figure 3 is a block diagram showing the major sections of this board. These functions are implemented by three custom chips.

When activated, the Ultrasonic Circuit Board applies to the transducer, at intervals of about 200 ms a 1-ms, chirped sequence of 14 pulses at 60 kHz, 57 kHz, 53 kHz, and 50 kHz. The pulses have an amplitude of 300 V. Four different frequencies are used to minimize the possibility that the reflection characteristics of the target and, perhaps, its surroundings might cause destructive interference, thus cancelling the reflected sound wave.

The received signal, which may represent a single reflected echo or a series of echoes from various targets, is boosted by a cleverly designed amplifier that incorporates 16 levels of time-dependent gain control. The echo from a nearby target is generally stronger and arrives sooner than the much weaker echo from a more distant target. Therefore, the automatic gain control feature provides substantially more gain for distant targets. As gain is increased, the amplifier's frequency response is simultaneously narrowed. This improves the receiver's noise immunity at very high gain levels.

Figure 4 is a graph showing the theoretical gain for the first eight steps. Steps 10 through 16 resemble step nine as shown in Fig. 5, with each successive step having a 4-dB gain increase.

Figure 5 also shows the binary gain control signals (GCA, GCB and GCC) generated by the timing and control circuitry on the Ultrasonic Circuit Board. Also shown in Fig. 5 is the narrowing of the amplifier's bandwidth at and beyond the eighth gain step. Note the parallel listing of echo times and distances to the target.

Figure 6 summarizes the entire transmission and reception sequence for a

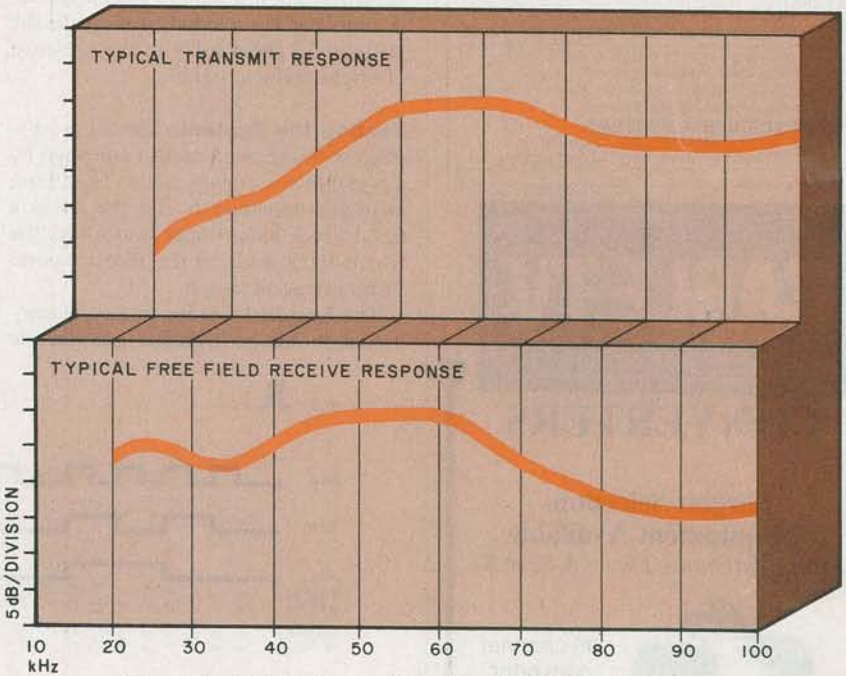

Fig. 2. Transmit and receive response of Polaroid's transducer.

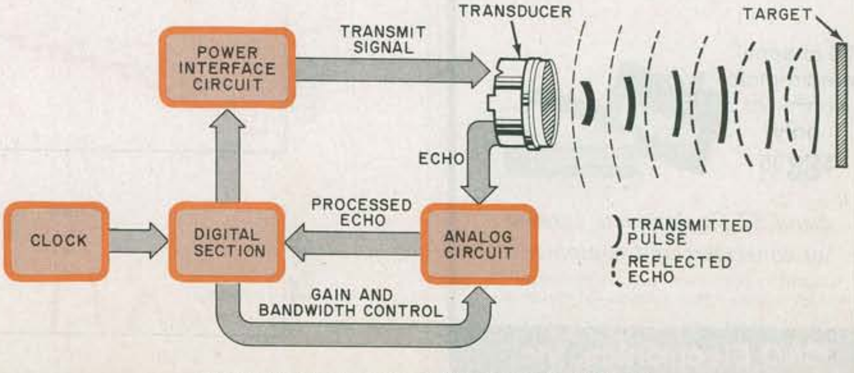

Fig. 3. Block diagram of Ultrasonic Circuit Board.

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single chirp directed against three targets within the detection field. Note how the circuit shapes each echo and then generates a clean, square pulse representing only the first echo. This signal is designatd MFLOG, and is available at pin 15 of the Ultrasonic Circuit Board. The transmitted chirp signal is available at pin 16 on the board. The time duration between these signals represents twice the distance to the target.

The Experimental Demonstration Board. The utility of Polaroid's Ultrasonic Ranging System kit is greatly enhanced by the Experimental Demonstration Board. This board is essentially a custom 3-digit counter that converts the echo time signals from the Ultrasonic Circuit Board into distance to the target to the nearest tenth of a foot. CMOS IC's are used throughout, and the range is displayed on a 3-digit LED readout. A red filter is included to increase the visibility of the display in the presence of bright ambient light.

Testing the System. The kit is supplied with the two boards connected by a 6-conductor ribbon cable. Therefore, all that's necessary to use the kit as a 0.9′-to-35.2′ rangefinder is to solder the two battery leads to the Experimental Demonstration Board.

The boards, transducer, and battery holder should be installed in a suitable enclosure. Temporarily I have used a compact 7″ × 6″ × 1″ wood cigar box. Holes for the display and power switch were cut through the box top, and a cir-

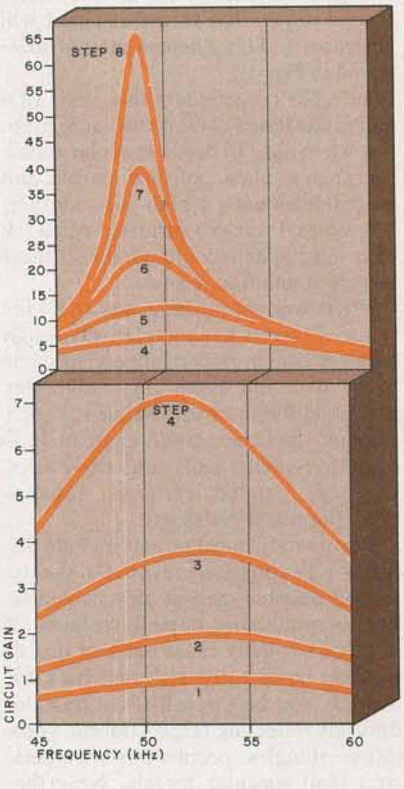
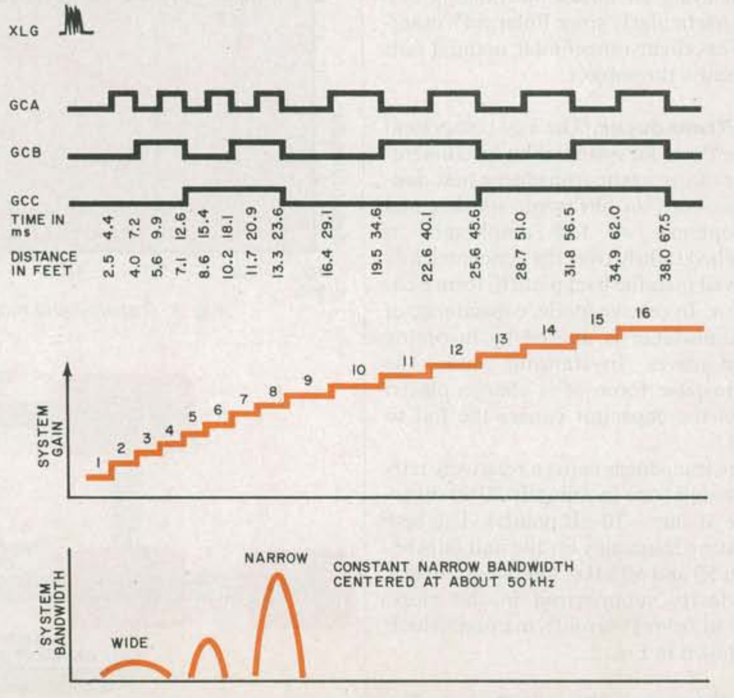


Fig. 4. First eight steps of receiver gain.



Artwork adapted from Polaroid Operation Manual.

Fig. 5. Operation of gain control logic circuit.

cular aperture for the transducer was made in the bottom of the box. An arrangement like this allows you to view range measurements while pointing the unit away from your face and other objects so that you're pointing toward targets of interest. Make sure the transducer leads do *not* become disconnected and that exposed metal parts of the transducer, including its connections, do *not* touch either board. For best results, of course, install the boards in a permanent metal or plastic enclosure.

Incidentally, Polaroid warns that the transducer *must* be properly connected to the Ultrasonic Circuit Board before power is applied. Otherwise, the high-voltage chirps may damage the board. One of the two transducers supplied with the kit is connected to the Ultrasonic Circuit Board by a short, shielded cable. If the cable connections are flexed frequently, be sure to inspect the solder connections at regular intervals to make sure they are secure.

Commercial Applications. One of the most interesting applications for Polaroid's rangefinder technology to reach the market is Tailmate™, a sophisticated detection system for trucks and trailers developed by Gregson Holdings Ltd. (382 Blackpool Road, Preston, Lancashire, PR2 2DS, England).

When a Tailmate-equipped vehicle is placed in reverse, the system is actuated, and the driver can then view a readout installed in the cab, which gives the distance to a loading dock or other object. If the driver wants to stop the vehicle a specific distance from an object, he can enter the distance into the Tailmate unit. Three feet before the preset distance is reached, the system emits a pulsed warning tone. When the desired distance is reached, a continuous tone is sounded. The system can also measure the distance to overhead objects.

Another application is the Sona Switch™, an indoor-outdoor object detection system designed for automatic door openers, vehicle detection, and security systems. The Sona Switch is a product of Electronic Design and Packaging Company (17425 Ecorse Road, Allen Park, MI 48101).

Other applications include robotics, vehicle height detectors, automatic controls for agricultural equipment, and measurement of the product level in silos and storage tanks. A particularly interesting application is a wheelchair guidance system that helps quadriplegics maneuver a motor-driven chair through narrow passages like doorways and halls.

Experimenting with the Rangefinder

THE Polaroid rangefinder can be used with little or no modification for many applications. You can even interface the device with a computer bus. If you want to try a specific application, details on how to convert the distance reading from the rangefinder into audible chirps are given in the following experiment.

An Audible Output. Some of the many useful applications for Polaroid's Ranging System can be enhanced by the addition of an output tone whose frequency

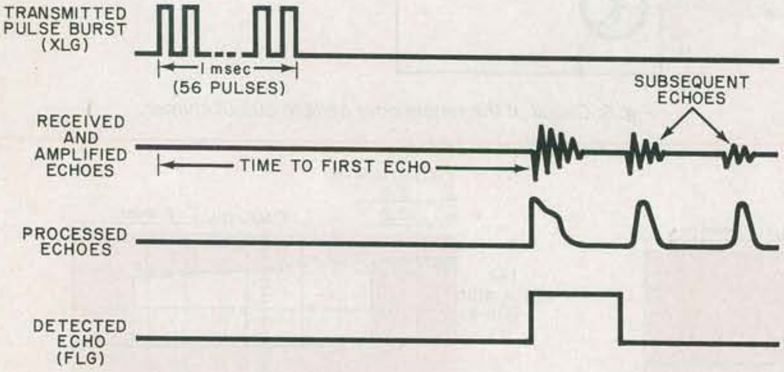


Fig. 6. Waveforms of the transmission and target detection sequence.

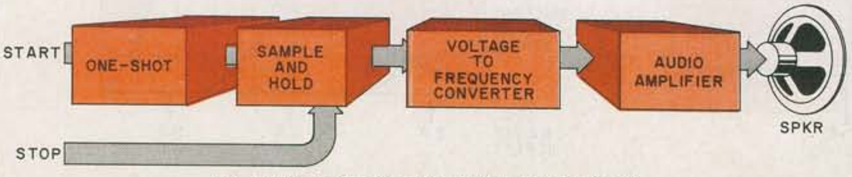


Fig. 7. Block diagram of audible output circuit.

varies with the range to the detected target. Figure 7 shows in block diagram form an experimental circuit I've designed that converts the echo time to this rangefinder into a chirped tone. A single chirp is produced for each rangefinding cycle.

Briefly, an ultrasonic burst from the ranging system triggers a one-shot that, in turn, causes the capacitor in a sample-and-hold circuit to begin charging. When the echo is received, the capacitor stops charging and is immediately discharged by an analog switch. During the time before the echo is received, a voltage-to-frequency converter produces a tone whose frequency increases with the charge on the capacitor. The result is a series of chirps. Nearby targets (short echo time) give low-pitched chirps, while distant targets (long echo time) give high-pitched chirps.

Circuit Operation. Figure 8 shows the complete circuit for the chirper. In operation, *Q1* and *Q2* serve as input buffers for the XLG (start) and MFLOG (echo time) signals from the Ultrasonic Circuit Board. The XLG signal triggers a 555 timer (*IC1*) configured as an astable multivibrator. The output from *IC1* (pin 3) remains high for a time determined by *R7* and *C2*.

The MFLOG signal is ANDed by *IC2A* and *IC2B*, and, when both signals are present, analog switch *IC3A* is closed. This allows *C4* to be charged through *IC3A* and *R8*.

The 555 timer, *IC4*, is configured as a voltage-to-frequency converter tone generator. Its control input is connected directly to *C4*. Therefore, as *C4* begins to charge, the oscillation frequency of *IC4* begins to rise.

When the echo arrives, the MFLOG signal goes low and the AND gate output also goes low. This opens *IC3A* so that *C4* is no longer charged. Simultaneously, *IC3B* is closed by *IC2A* and the voltage on *C4* is dumped to ground. The voltage-to-frequency converter immediately stops oscillating. Depending upon adjustments of *R7, R8* and *R9*, the audio output from the circuit ranges from low-pitched thumps (nearby objects) to high-pitched chirps (distant objects).

You can better understand the circuit's operation by referring to the oscilloscope waveforms in Figs. 9 and 10. The upper trace in Fig. 9 shows the 1 ms tone burst that is applied to the ultrasonic transducer by pin 16 of the Ultrasonic Circuit Board. The lower trace shows the square wave that begins with the transmitted tone burst and ends when the first echo is received. It appears at pin 15 of the Board.

Figure 10 shows the critical waveforms in the chirp generator circuit for three different target ranges (2.4′, 6.3′ and 9.5′). The upper trace shows how the echo time is increased for each of these ranges. In one millisecond, sound travels approximately 0.89′. Therefore, the round trip time for the 9.5′ range should be 9.5′ × 2′ × 0.89′ or 16.9 ms. This is in close agreement with the indication of about 16.75 ms on the lower trace in Fig. 12.

Using the Circuit. Operation of this circuit is very much dependent upon the settings of potentiometers *R7, R8,* and *R9.* Potentiometer *R7* controls the one-shot's pulse duration. If it is set to produce a pulse whose duration exceeds the time between range cycles (about 200 ms), the output sound will be a series of double or triple thumps or beeps.

Potentiometer *R8* controls the charging time of *C4*. If its resistance is too low, the voltage-to-frequency converter will produce a steady tone. If its resistance is too high, the voltage of *C4* may take too long to reach the levels required to alter the tone from *IC4.*

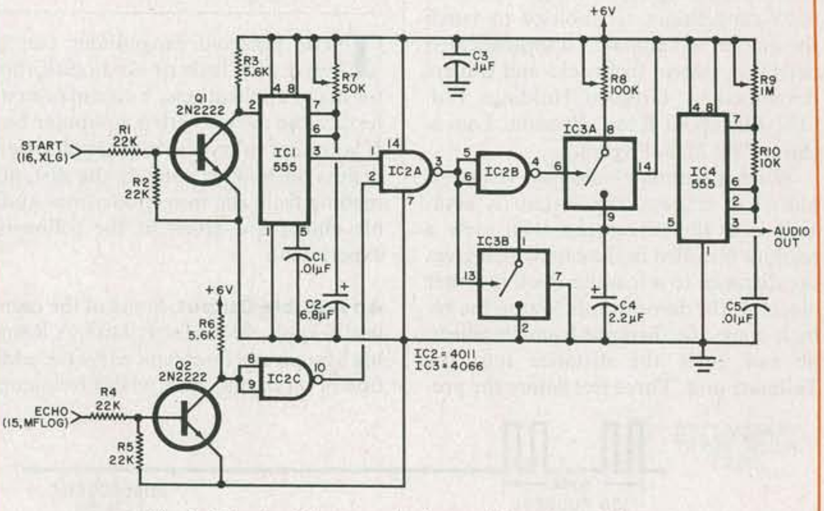


Fig. 8. Circuit of the rangefinder audible output chirper.

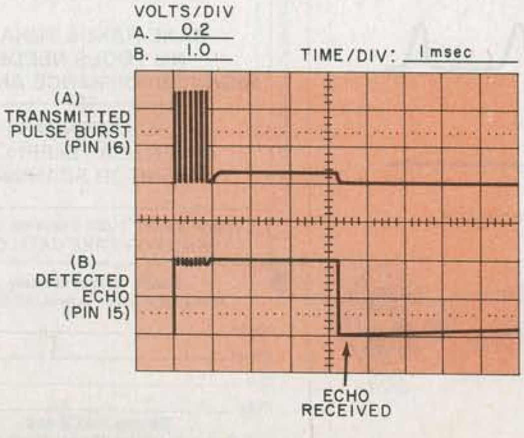


Fig. 9. Waveforms at target detection.

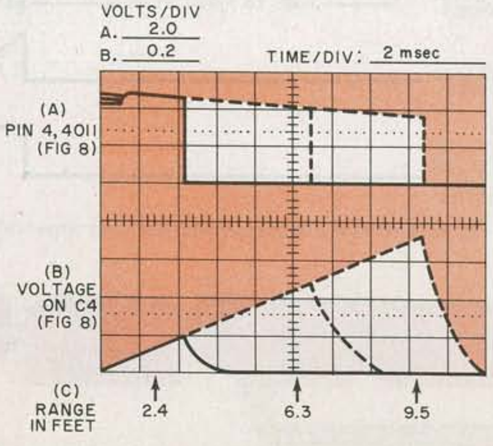


Fig. 10. Waveforms of audible output circuit.

Finally, *R9* controls the pitch of the chirps. For best results, set *R9* to produce very-high-pitched chirps when the system is detecting very distant targets. Nearby targets will then give a characteristic thump . . .thump . . .thump . . .

Going Further. The circuit is Fig. 8 is not optimized, and many variations are possible. For example, you can replace *C4* with a piezoelectric alerter (Radio Shack part #273-065 or similar). The alerter will emit tone bursts whose *duration* is perceptibly longer when distant targets are being detected. Since all the bursts are brief, no matter what the range, longer pulses from the alerter seem louder than very short pulses. The overall effect provides an interesting alternative to the voltage-to-frequency converter chirped tone output.

LM3905 Ap Note

THOUGH less well-known than its 555 predecessor, the LM3905 is a precision timer with a host of applications. Capable of operating from unregulated supplies of 4.5 to 40 V, the LM3905 and its LM122/LM222/-LM322/LM2905 counterparts can provide constant timing periods ranging from microseconds to hours. Variations in the supply voltage alter the timing period by less than 0.005% per volt. Therefore, poorly or unregulated supplies with considerable ripple can be used. The chip typically consumes only 2.5 mA in the quiescent state (that is, no external load being driven).

Figure 11 is a straightforward on-after-delay timer given in National Semiconductor's data sheet on the LM3905. This circuit nicely simulates a thermal time-delay relay of the kind often used to apply power to a circuit at a fixed interval after a main switch is closed.

Operation of the circuit in Fig. 11 is straightforward. When *S1* is closed, the LM3905 enters a timing cycle with a duration of *R1C1* seconds. After the cycle is completed, the relay is actuated. Diode *D1* protects the LM3905 from back emf produced by the relay coil when *S1* is opened.

For variable delays, use a 1-megohm potentiometer for *R1*. For very long delays, use large values for *C1*.

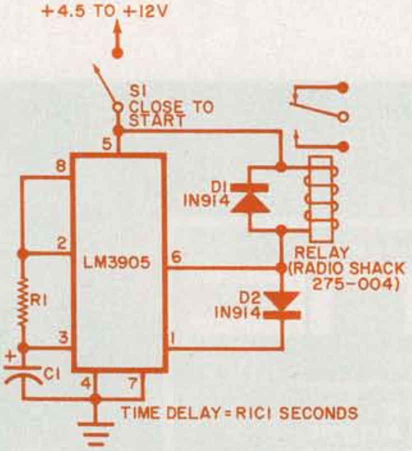


Fig. 11. On-after-delay timer.

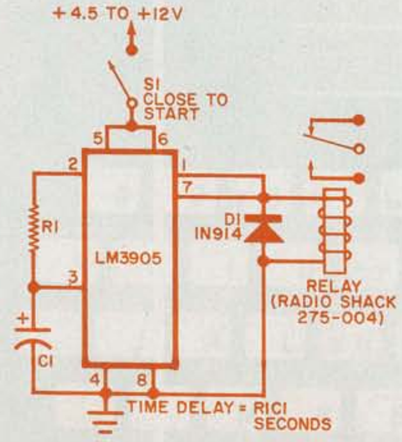


Fig. 12. Off-after-delay timer.

Incidentally, the circuit can be easily modified as shown in Fig. 12 to operate in the converse manner. In this configuration, which is also given in the LM3905 data sheet, the relay is closed when *S1* is closed. After a time interval of *R1C1* seconds, the relay is opened.

For those of you who are skeptical about circuits given in application notes, such as the two discussed here, you can be assured I've breadboarded both these timers. They work just as described.

The Move to Lower Supply Voltages

BEFORE the end of this decade, 5-V logic systems may be as scarce as RTL chips and watches with LED displays. That's because a major move is now underway to standardize logic circuits for operation at 3 V.

Already most CMOS chips are specified for a minimum supply voltage of 3 V. A major impetus for the proposed new standard is that even this minimum is appreciably close to breakdown ratings as low as 5 V that characterize new smaller ICs.

Warren Andrews has reported in *Electronic Engineering Times* that the proposed new 3-V supply standard is slated to apply to both MOS and bipolar linear and digital chips (January 3, 1983). A committee of the Joint Electronic Devices Council (JEDEC) has already approved a 3.3-V (±0.3 V) standard for line-operated regulated supplies and a 2-to-3.6-V standard for battery powered operation.

Two supply standards will satisfy both TTL and MOS manufacturers. The tolerance margin of the 3.3-V standard for regulated supplies will guarantee that TTL circuits are powered by at least 3 V and, therefore, provide a comfortable margin above TTL's guaranteed minimum high-state output (V_{OH}) of 2.4 V.

The battery supply standard covers a wider voltage range to allow for the great variety of battery chemistries and discharge characteristics. The 2-V minimum is within 10% of the 2.2-V potential of single lead-acid storage cells. The 3.6-V maximum matches the maximum for the recommended regulated supply voltage and leaves room for a single lithium cell (2.8 V), two mercury cells in series (2.7 V), two alkaline or carbon-zinc cells in series (3 V), or two nickel-cadmium storage cells in series (2.4 V).

The proposed new voltage standards must be approved by several additional

JEDEC committees before final consideration by the JEDEC council. David Ford, chairman of the JEDEC committee that proposed and approved the new standards, was quoted by *Electronic Engineering Times* as having said, "The reaction to the proposed standards is basically positive."

Adoption of the new standard will have several important long-term impacts on solid-state electronics. For example, line-powered supplies will require the development of 3-V regulator chips and low secondary voltage transformers. Three-volt zener diodes will become more widely available.

The most important result of the new standards will be even more growth in the variety and availability of portable battery-powered electronic devices. Certainly, single lithium 2.8-V power cells will become the battery of choice for nearly all such devices. We can therefore expect to see better availability and important price reductions for lithium cells.

Conventional mercury, alkaline, and carbon-zinc chemistries can also be used to meet the new standard, but only in a series arrangement of two cells. Meanwhile, the familiar 9-V transistor radio battery will eventually be relegated to older equipment and special-purpose applications. If competition drives prices down, single lithium cells might even capture a big share of the market that now exists for standard cells.

These speculations should be tempered with the knowledge that a continued reduction in IC fabrication dimensions may eventually require an even lower power supply standard of about 2 V or even less. If this occurs, new or modified battery chemistries may be required. In any event, the rapid advances in IC fabrication technology and the move to lower voltage standards are sure to bring many important changes.

Device Developments

The Iso-Gate™ Optoisolator. Dionics, Inc. (65 Rushmore St., Westbury, NY 11590) announced more than a year ago the development of miniature integrated photovoltaic diode arrays. The company has recently introduced a series of novel optoisolators that employ an infrared-emitting diode and one or two of the new photovoltaic diode arrays to directly drive the gates of power MOSFETs. According to Bernard L. Kravitz, Dionics' president, "Since the output voltage of the Iso-Gate is self-limited by its very construction, it becomes physically impossible for an Iso-Gate to deliver a harmful voltage to the MOSFET."

Iso-Gates can enhance the design and reliability of both switching (for example, a solid-state relay) and analog MOSFET circuits. Kravitz observes, "Some examples of these non-relay MOSFET functions are amplification stages, motor-control circuits, and switching power regulators. In all of those, there is a great advantage in driving the delicate gate of the MOSFET with an optoisolated, self-generated, and self-limited voltage source that is truly 'floating'." Since the output of the photovoltaic half of the new optoisolators is highly linear with respect to the forward bias applied to the infrared emitter, the new optoisolators may find applications in such linear roles as isolation amplifiers and frequency-to-voltage converters.

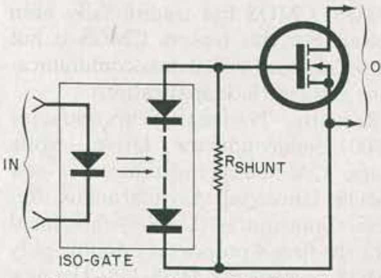


Fig. 13. Iso-Gate MOSFET driver.

Figure 13 shows a typical Iso-Gate MOSFET driver circuit. The resistor R_{shunt} discharges the residual voltage remaining in the photovoltaic array (by virtue of its parasitic capacitance) when illumination from the infrared-emitting diode is suddenly removed. Depending upon the device, optimum values of R_{shunt} range from 1 to 10 megohms. For faster switching speeds, Dionics recommends paralleling the Iso-Gate with a phototransistor optoisolator or a second Iso-Gate.

Dionics now sells five Iso-Gates. The three devices in the DIG-11 series are installed in 6-pin DIPs. Included is a single infrared-emitting diode and photovoltaic diode array. They deliver a minimum self-generated, fully-floating, open-circuit output of 6 V when their infrared-emitting diodes are driven with a forward current of 30 mA. Depending upon the device, the short circuit output current ranges from 2 to 30 μA. Prices in 1000-lot quantities range from $1.32 to $1.87.

The DIG-122 series includes two devices housed in 8-pin DIPs. These devices include two independent photovoltaic diode arrays which, when connected in series, deliver from 12 to 17 open-circuit volts. The short-circuit output current ranges from 1.5 to 9μA. In 1000-lot orders they are $1.82 and $2.13.

(Continued overleaf)

New Peripheral Controller Chips. Rockwell International's Electronic Devices Division (4311 Jamboree Rd., PO Box C, Newport Beach, CA 92660) has introduced four new single-chip, 8-bit intelligent peripheral controllers (IPC). These new controllers are actually 6502 microprocessors with on-chip hardware designed specifically to enhance their role as controllers of motors, printers, typewriters, robots, instruments, and communications equipment.

All four of the new IPCs include a parallel-host data bus compatible with the 6500/6800 and 8080/Z80 microprocessor families. They also include on-chip input, output, and status and control registers for data transfer functions. All four chips have on-chip 64 × 8 bit RAMs. Three of the chips have on-chip ROMs, thus making them well suited for motor and keyboard control, small printer line buffering, and many other peripheral control functions.

New CMOS A/D Converters. Texas Instruments has introduced a series of four analog-to-digital converter chips that are claimed to simplify the task of interfacing analog signals with 8- and 16-bit microprocessors. The new chips, designated TL530, TL531, TL532 and TL533, feature an 8-line TTL compatible bidirectional data bus. Also included are on-chip multiplexers and 16-bit analog and digital data registers. According to Texas Instruments, these features make it relatively simple for a microprocessor to collect multiple analog and digital inputs with a minimum of hardware and processing time.

Figure 14 shows these new chips and a block diagram summarizing their operation. The TL530 and TL531 are 40-pin units that can accept up to 15 analog inputs and 12 digital inputs. The TL532 and TL533 are 28-pin chips that accept up to 11 analog and 6 digital inputs. Six of the inputs of all four chips are multipurpose and can accept either analog or digital signals. If some of these specifications seem familiar to experienced A/D users, it's because the TL530 and TL531 can be used as functional replacements for the 74C924 and MC144444; and the TL532 and TL533 for the 74C934.

These new chips feature maximum conversion times of 300 μs. They typically consume 15 mW and require a single 5-V supply. In 100-lot quantities, the TL533 sells for as little as $4.32. Write Texas Instruments' Literature Response Center (SC-389, PO Box 202129, Dallas, TX 75220).

A Fast CMOS UART. Though CMOS consumes considerably less power than NMOS, CMOS has traditionally been slower. For this reason, CMOS is not yet widely used in fast data communications and interface applications.

Recently, National Semiconductor (2900 Semiconductor Drive, Santa Clara, CA 95051) introduced a new CMOS Universal Asynchronous Receiver-Transmitter (UART) fabricated with the firm's proprietary double-poly CMOS process, p^2CMOS-11™. The new chip, which is designated the NSC858, operates at up to 1 million bits per second. The chip typically consumes 50 mW. It includes a programmable on-chip baud-rate generator that can accept clock rates up to 3.1 MHz and divide them by 1 to 216.

In addition to various standard UART features, the NSC858 includes each of the five standard MODEM control functions, a processor interrupt system to minimize processing time required to control the UART, and complete hardware and software power-down capabilities. ◇

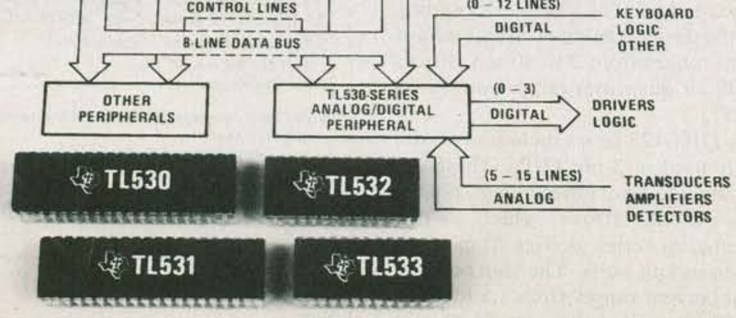


Fig. 14. Block diagram shows operation of TI's CMOS A/D converters.

OPERATION ASSIST

If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist. Computers & Electronics, *1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)*

Philco Model 46-1226-122 record player. Need schematic or out of print Sams Photofact 15-24. Lee Stirm, 3230 Collins, Garland, TX 75042.

Measurements Model 80-R signal generator. Need schematic. D. Boone, Box 330, Valley Mills, TX 76689.

Rapid Printer Model 2001 printing calculator. Need schematic and service manual. Fred Feaver, 105 Townsend Ave., Burlington, Ontario, CAN L7T1Y8.

Western Electric Model 300 data phone modem. Need schematics or technical information. Harold Wright, 7144 Center St., Highland, CA 92346.

Dumont Type 274-A cathode ray oscillograph. Need schematic and operating instructions. T. J. Laube, 6834 Alpert Dr., Orlando, FL 32810.

Scott Marine Radio Model SLRM. Need schematic and manual. Mike Curry, 3 Parmly St., Rumson, NJ 07760.

Panasonic Model CT-702 television. Need schematic or any technical information available. Mike Adams, Box 411, Mt. Vernon, WA 98273.

Aerotron Model 500 vhf transceiver. Need operating manual and schematic. Gerald Stephens, 1212 N. Monroe, Decatur, IL 62522.

RCA tube manual. Need manual printed in early 1940's. Alvin Smith, 1940 S. Dorh St., Ukiah, CA 95482.

Lafayette Model RK-815 tape recorder. Need drive motor belt, operating manual and schematic. Michel Placias, 2029 Ala Wai PH2, Honolulu, HI 96815.

General Radio Model 916A bridge. Need generator and detector cable connectors. Ronald Dement, 755 Quincy Avenue, Bronx, NY 10465.

Monsanto Type 105A frequency counter. Need service manual and schematic. Jerry Barnes, 637 Pinehurst Drive., Richardson, TX 75080.

Phillips Model PR 9400 pH meter/voltmeter. Need schematic diagrams. Ignacio L. Aliaga, Apartado 299, Chiclayo, PERU

RCA Model T7-5 radio. Need parts list and schematic. **Garrard** Model 6-300 turntable. Need parts and manual. Ron R. Backen, Box #51, Lake Elsinore, CA 92330.

Clegg Labs Model 99, 6 meter transceiver. Need schematic and operating manual. Jimmy J. Cheek, 2202 Windover Dr., N.E., Huntsville, AL 35811.

Hallicrafters Model S-120 receiver. Need schematic and operating manual. Bob Barteau, 4200 Vaile, Florissant, MO 63034.

Knight Model KG-625 VTVM. Need schematic and manual. Bill Johnson, 8156 E. 31st Court, Tulsa, OK 74145.

Hollingsworth Model P U-33/G military l0 kw generator. Need schematic and service manual. Stan Lovingfoss, Crafton Hills College, 11711 Sand Canyon Rd., Yucaipa, CA 92399.

Simpson Model 488 TV Field Strength Meter. **Deforest's Training Inc.** Model 101 2" oscilloscope panel. Need instruction manuals and schematics. H.E. Thompson, Box 15, Stouts Mills, WV 26439.

RCA Model AR 8506 B Radiomarine receiver and Model BC 474 A Receiver Transmitter. **Simpson** Model 415 Signal Generator. **Dumont** Model 247 Oscilloscope. Need schematics and service manuals. William D. Eramo, 51 Suffolk Ave., Revere, Mass. 02151.