ULTRASONIC RANGING SYSTEM

Description, operation and use information for conducting tests and experiments with Polaroid's Ultrasonic Ranging System components.
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Polaroid Ultrasound Ranging Unit

Introduction
The purpose of this manual is to familiarize you with the Polaroid Ultrasound Ranging Unit. It is intended to provide enough detail so that you can easily conduct tests and experiments with this device to determine its suitability to your needs.

*This kit is intended for experimental use only.*

The first section of this manual is a brief overview of the major components of the system and their functions. The second section contains the information you will need to operate and interface with this device. In addition, typical waveforms, timing diagrams, schematics and characteristic graphs are included.

Section three describes the experimental demonstration board included in this kit. This board will enable you to immediately begin your evaluation of the ranging unit with a minimum of effort.

At the end of this manual, you will find technical specification sheets. We at Polaroid look forward to your continued interest in our ultrasound products as well as the other Polaroid products included in this kit.

Please note that components other than the ultrasound transducer are available for sale.

This kit comes complete with:

1. Polaroid Instrument-Grade Electrostatic Transducer Part No. 604142
2. Polaroid Ultrasonic Ranging Board (modified) either four-frequency Part No. 606745 or single-frequency Part No. 607089
3. Experimental Demonstration Board
4. Polaroid Circular Polarizer
5. Polaroid Polapulse Batteries Part No. 604152
6. Polapulse Battery Holder Part No. 604145
7. Cable Assembly Part No. 604789
8. Assorted Connectors and Wires

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I—GENERAL DESCRIPTION

Two primary components comprise the Polaroid Ultrasonic Ranging Unit: they are an acoustical transducer and ranging circuit board (Figure 1).

Together these components are capable of detecting the presence and distance of objects within a range of approximately 0.9 feet to 35 feet. In operation, a pulse is transmitted toward a target and the resulting echo is detected. The elapsed time between initial transmission and echo detection can then be converted to distance with respect to the speed of sound. For a transmitted pulse to leave the transducer, strike a target two feet away, and to return to the transducer, requires an average time lapse of 3.55 milliseconds.

FIGURE 1. BLOCK DIAGRAM — RANGING CIRCUIT BOARD/TRANSDUCER
The principal component in this device is the transducer (Figure 2), which acts as both loudspeaker and microphone. It has been designed to transmit the outgoing signal and also to function as an electrostatic microphone in order to receive the reflected signal (the echo). Its diameter determines the acoustical lobe pattern, or acceptance angle, during the transmit and receive operation. A special, Polaroid manufactured foil is stretched over a grooved plate, forming the moving element which transforms electrical energy into sound waves and the returning echo back into electrical energy. The grooved, metallic backplate in contact with the insulating side of the foil forms a capacitor which, when charged, exerts an electrostatic force to the foil. The foil is pliable, capable of resisting harsh environments, and an excellent electrical conductor.

Note: Polaroid Corporation offers two grades of electrostatic transducers for sale; Instrument Grade and Commercial Grade. The Instrument Grade transducer is included in this kit to meet the performance demand of the ultrasonic circuit board to range between 0.9 feet and 35 feet. If your application is less demanding, or different from our technique of distance ranging, the Commercial Grade transducer may be more appropriate. Please be aware that the ranging circuit board, as described in this manual, is not guaranteed to operate reliably with anything but Polaroid's Instrument Grade electrostatic transducer.

Under no circumstances should the user attempt to open or rebuild the transducer as this will change its acoustical characteristics.

**WARNING:** Be certain that the transducer is properly connected to the ranging circuit board before applying power. Applying power to the board with the transducer disconnected may damage the board.

When the unit is activated, the transducer emits a sound pulse, then waits to receive the echo returning from whatever object the sound pulse has struck. The emitted pulse is a high-frequency, inaudible "chirp," lasting for about one millisecond and consisting of fifty-six pulses. In the four-frequency version of the board, these are at four carefully-chosen, ultrasonic frequencies: 60 kHz, 56 kHz, 52.5 kHz, and 49.1 kHz. Occasionally, a single frequency could be cancelled because of certain target topographical characteristics, and no echo would be reflected. This device uses four frequencies to overcome that
possibility. Since in practice it has been found that most applications do not require this four-frequency tone burst, a single-frequency version of the board is also used where all fifty-six pulses are at 49.1 kHz. The electronics are most responsive to this frequency, so some efficiency is gained in this version. Both boards are used interchangeably in the designer's kit. See section four of this manual for a further description of the single-frequency unit.

The ranging circuit board electronics (Figure 3) control the operating mode (transmit/receive) of the transducer. It is comprised of three major sections, which control transducer operation and allow the information gathered by it to be used as desired. Among the sections are: a digital circuit, an analog circuit and a power section.

Powered by a 6 VDC supply, capable of 1 millisecond current surges of at least 2.5 amps, an appropriate drive circuit initiates the transmission of an ultrasonic pulse by the transducer (Figure 4). (Several drive circuits are described later in this book.)

A crystal-controlled clock in the digital circuit generates the ultrasonic frequencies that comprise the pulse transmitted by the transducer.

After generating the “chirp,” the operating mode of the transducer changes, in effect, from loud-speaker to microphone to detect the returning echo. Upon receiving the echo, the transducer converts the sound energy to electrical energy, which is amplified by the analog circuit, then detected by the digital circuit to produce the echo received signal.

**WARNING:** A 300 volt signal is applied across the transducer each time a “chirp” is transmitted. Anyone contacting this signal during transmission will feel a noticeable, but harmless, shock.

Because of the reduction in return signal strength (echo) over longer distances (return signal power at 35 feet is almost a million times weaker than at 3 feet), a dual role is played by the amplifier within the analog circuit. In addition to processing the echo, the amplifier also performs the function of maintaining a tailored sensitivity over the entire operating range (distance covered) of the system. Lower amplification is needed for close echoes, while higher amplification is needed for distant echoes. The change in amplification is accomplished by increasing the gain and the Q of the amplifier in eight steps, out to 13.3 feet, and then by increasing just the gain of the amplifier, again in eight steps, beyond 13.3 feet. For optimum performance, a tailored sensitivity over the entire operating range is important and necessary.
NOTE: The overall gain can be adjusted by changing R1 (16, Fig 5). Increasing the value of R1 will increase system gain. If potentiometer R6 (13, Fig 5) is installed, the system gain can also be adjusted with the variable resistor. If R6 is not installed, the overall gain can be reduced by relocating C2 (11, Fig 5) and installing a potentiometer (25 Ω, 1/2 W-R6) in its former location. Excessive gain may cause a false receive indication just after transmit; insufficient gain may cause intermittent, far-field detection.

In our camera systems we maintain one strict rule concerning our ultrasonic modules. From time of transmit to receive, we inhibit all other high-current electronic or electro-mechanical camera activity. This insures as noise-free an environment as possible. This is important because in the later high-gain steps, the Ranging Circuit Board is very susceptible to noise. The user should be aware of this when interfacing the Ranging Circuit Board with other electronics.

With this brief description as a base, pertinent operating details will now be presented as an aid in using the system and in establishing and monitoring its performance.
Following are suggested circuits and circuit-board modifications that enable the Ranging Unit to be examined and used in various ways. Bear in mind that these are only suggestions to help you get started. There may be other ways to adapt this module to your needs; however, these circuits will allow immediate use of this device for your evaluation.

Figures 5 and 6 are component-layout and schematic diagrams respectively. Refer to these figures to familiarize yourself with the circuit boards.

**FIGURE 5. COMPONENT LAYOUT**
NOTE: Production of drive signal MDL will be described in Part C of this section of this book. Timing relationships should not be established with respect to this signal, because the transmit signal (XLG, para. 2 below) does not start at a time that is precisely repeatable after the application of power.

Components in the VSW circuit, identified with an asterisk (*), comprise a speed-up circuit to allow rapid cycling. With the speed-up circuit, off-time can be as short as 40 ms. If rapid cycling is not desired, those components identified with an asterisk (*) can be omitted.

2. Transmission (XLG)

XLG (Figure 7) is the digital logic drive for the transmitted signal. With the single-frequency version it consists of fifty-six cycles at 49.41 kHz. With the four-frequency version, it consists of eight cycles at 60 kHz, eight cycles at 56 kHz, sixteen cycles at 52.5 kHz, and twenty-four cycles at 49.41 kHz for a total of fifty-six cycles and lasts for a period of about 1 millisecond. All timing relationships between transmitted signals and received echos are determined from the leading edge of this signal.
FIGURE 7. WAVEFORMS

FIGURE 8. MODIFIED RANGING CIRCUIT BOARD-FOUR FREQUENCY

NOTE: See page 29 for alternate equivalent interface circuits.
The interface circuit for extracting this signal is shown at the bottom of Figure 8. The input signal for this circuit is obtained at terminal 16 of the ultrasonic circuit board.

3. Amplified Echo

The amplified echo (Figure 7) can be observed at pin 6 of U1 (Figure 8). This signal is useful for observing the reflected echoes. Echoes below detector threshold may also be viewed here. Normally this signal would not be extracted; however, this is the place to look when adjusting the gain of the module.

4. Processed Echo

The processed echo (Figure 7) can be observed at pin 9 of U1 as shown in Figure 8. The decay time of this signal may be shortened by shunting capacitor C4 with a resistor of at least 100k ohms. C-MOS circuits (Figure 10), or circuits of at least one megohm input impedance, provide a convenient way to extract this signal, if desired. This signal is useful if echos, other than the first echo, are of interest.

5. Detected Echo (FLG)

FLG (Figure 7) is the signal which indicates that the echo (the reflected transmission signal) has been received. It is obtained from terminal 15 of the ultrasonic circuit board. The interface circuit for extracting FLG is shown at the top of Figure 8, and is identical with that used for XLG.
B. GAIN CONTROLLING LOGIC

Three logic signals control the system gain and bandwidth as a function of time. The timing and performance relationships between the logic signals, gain and bandwidth are shown in Figure 11.

The gain controlling logic can be observed at the following points (Figure 6):

- GCA at pin 14 of U1
- GCB at pin 13 of U1
- GCC at pin 12 of U1

Interface circuits, identical to those used for FLG and XLG, can also be used for these gain signals. Gain changes can be made by changing resistor R1 on the circuit board (Figure 5) and by adjusting potentiometer R6 if installed.

NOTE: The bandwidth changes continuously with time in eight steps, but is continuously narrow for the second eight steps and centered at about 50 kHz (see Figure 12).
C. SUGGESTED DRIVE CIRCUITS

As mentioned in part A.1. of this section, the production of drive signal MDL will be discussed here. Although there may be other methods for driving the ultrasonic unit, these circuit configurations have been tested and found to perform well while being simple to construct. In addition, they will enable you to quickly use and evaluate the ultrasonic unit.

The primary components in the following configurations are C-MOS devices (74C14 hex Schmitt triggers) which work quite well as drive circuits.

Figure 13 is a symmetrical drive, suitable for generating one-to-five repetitions per second (rps). Both pulse duration and off-time are approximately equal to T=RC.

Figure 14 is an asymmetrical drive, capable of providing up to 10 rps with long "on" symmetry. As above, pulse duration is approximately equal to $T_1=R_1C$; however, off-time is equal to approximately:

$$T_2 \approx \frac{R_1R_2}{R_1 + R_2} \times C.$$

Figure 15 is also an asymmetrical drive; however, it is designed to provide as little as 4 repetitions per minute with long "off" symmetry. Pulse duration is approximately equal to:

$$T_1 \approx \frac{R_1R_2}{R_1 + R_2} \times C;$$

off time is approximately equal to $T_2 \approx R_1C$. 

*NOTE: Only the graphs of the first eight gain steps are included here for clarity. Steps 9-16 are identical to step 8 except that each successive step is increased in gain by 4 db. These graphs are generated from theoretical information, not experimental data.

FIGURE 12. POLAROID ULTRASONIC RANGING UNIT GAIN VS. FREQUENCY*
Figure 16 is included here for its application value rather than as a general drive circuit. It is a method of cycling several systems in sequence repeatedly so that they do not interfere with each other.

This circuit is a digital system utilizing a symmetrical drive. (All components are identified on the drawing.) Very slow repetition rates can be achieved with this circuit, and it can be used to drive up to eight modules in sequential order.

**FIGURE 13. SYMMETRICAL DRIVE**

**FIGURE 14. ASYMMETRICAL DRIVE**

**FIGURE 15. SLOW ASYMMETRICAL DRIVE**
FIGURE 16. MULTIPLE SYSTEMS

WITH SYMMETRICAL CLOCK,
DUTY CYCLE IS 1/16

MAY USE WITH 1 TO 8
MODULES
Figure 17 is a fixed-gain test circuit. It is a simple circuit that may be built from readily available parts. The circuit produces a single frequency transmit burst of 8, 16, 32 or 64 cycles and repeats at regular intervals of about 200 ms. It features adjustable blanking, a fixed gain amplifier, a detector and complementary, buffered, echo-detect outputs. The transmit frequency is adjustable by means of a potentiometer.

This circuit is intended as a starting point in arriving at a system design where the sophistication of the ultrasonic circuit board is not needed.

NOTE: TR can be either:
1. Ferroxcube 1107 A250 core wound with
   Primary = 5 turns #32 copper wire,
   Secondary = 220 turns #38 copper wire or
2. Ferrite Rod 3/4" long by 5/32" diameter wound with
   Primary = 30 turns of #28 copper wire,
   Secondary = 1000 turns of #44 copper wire or
3. Polaroid Transformer part No. 605541

FIGURE 17. FIXED-GAIN TESTER CIRCUIT
DESIGN CONSIDERATIONS IN ULTRASONICS

Power Supply:
Designer's Kit will operate from 4.9 to 6.8 volts. The power supply must be able to handle the high current transient (2.5A).

Range: (with user custom designed processing electronics)
  Farther
  a. Use an acoustic horn to "focus" the sound (narrowing the beamwidth).
  b. Use two transducers - 1 receiver and 1 transmitter - facing each other.
  c. Lower the transmitting frequency (which will decrease the attenuation in air).

  Closer
  a. Use a shorter transmit signal (such as four cycles of one frequency).
  b. Use two transducers - one to transmit, one to receive (eliminates waiting for damping time).

Resolution
  a. Above all, know the target and range well, and design a system with them in mind.
  b. Use a higher transmit frequency.
  c. Look at phase differences of a given cycle of the transmitted signal and received echo (as opposed to using an integration technique).
  d. Increase the clock frequency of the counter.

Accuracy: (again, you must have a well defined target)
  Temperature Compensate
  a. Use a second small target, as a reference, at a known distance in the ranging path (such as a ¼" rod several feet away), process both echoes, then normalize the second distance with respect to the first, since t1/d1 = t2/d2.
  b. Incorporate a temperature sensing integrated circuit to drive a VCO to do the distance interval clocking.

Beam Width:
  Increase
  a. Use an acoustic lens (to disperse the signal).
  b. Decrease the transmitting frequency.
  c. Use several transducers to span an area.

  Decrease
  a. Use an acoustic horn (to focus the sound).
  b. Increase the transmitting frequency.

BIBLIOGRAPHY

Microphones & Microphone Preamplifiers, Brüel & Kjaer Catalog.
III—EXPERIMENTAL DEMONSTRATION BOARD

A. GENERAL DESCRIPTION

The experimental demonstration board (EDB) enables ranging to be performed with the Polaroid Ultrasonic Ranging Unit. A digital readout displays measured distances five times each second in tenths-of-a-foot. It has a range of 0.9 feet to 35.0 feet.

WARNING: Be certain that the transducer is properly connected to the ultrasonic circuit board before applying power. Applying power to the board with the transducer disconnected may damage the board.

The EDB has all the necessary circuitry to interface with the Ultrasonic Ranging Unit (Figure 18).

The acoustical transducer is connected to the ultrasonic circuit board which, in turn, is connected to the EDB. The EDB provides the circuit board with a switching voltage, a constant plus voltage and a ground return. The circuit board provides the EDB directly with the transmit signal and the received echo signal.

A time-window, directly related to distance, is generated by the transmit signal and the received echo. A 420 kHz clock on the EDB allows accurate measuring of this time-window.

The switching voltage applied to the circuit board causes it to transmit and receive repeatedly, providing a new time-window each cycle. After each cycle, the EDB measures the time-window, converts the time-window into distance and displays the distance digitally until the next cycle updates the information.

FIGURE 18. BLOCK DIAGRAM
B. SYSTEM INTERCONNECTIONS
(Figure 19)

Connect the acoustical transducer to the ranging circuit board. Connect the center conductor of the coaxial cable between the positive (+) transducer terminal and terminal 2 on the board. Connect the shield between the negative (−) transducer terminal and terminal 1 on the board.

A 6 volt, 2.5 ampere power supply must be connected to the EDB. The plus (+) 6 volt wire connects with terminal # 6 on the EDB. The ground from the power supply connects with terminal # 7.

NOTE: A power supply of lower amperage rating can be used if a storage capacitor of about 500 mfd is placed across the power line at the board.

The EDB provides switching voltage VSW. Connect terminal # 5 to VSW (red lead) on the ranging circuit board.

NOTE: To switch the circuit board, pin #10 on the Interface Chip has been disconnected on the four-frequency board. Other alterations, to both four-frequency and single-frequency boards, are shown in section four.

The EDB provides constant voltage +VCC and ground return GND. Connect terminal # 4 to VCC (orange lead) and terminal # 3 to VCC (yellow lead) on the circuit board. Connect GND terminal # 8 to GND (brown lead) on circuit board.

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FIGURE 19: INTERCONNECTIONS (EDB) ULTRASONIC RANGING SYSTEM
The ranging circuit board provides EDB with the transmit signal and the received echo. Connect terminal #1 on the EDB to XLG (blue lead) on the circuit board. Connect terminal #2 on the EDB to terminal FLG (green lead) on the circuit board.

There are six connections between the EDB and the circuit board. There are two connections from the EDB to the power supply. There are two connections between the transducer and the ultrasonic circuit board. These ten interconnections are required to demonstrate the Ultrasonic Ranging System.

A one-inch square of Polaroid, circularly-polarized filter (red) is included in this kit to increase the readability of the display. To correctly orient the filter, place it over a shiny silver coin such as a nickel or quarter. If the coin is visible through the filter, turn the filter over - the coin should now be much darker or not visible. The filter is correctly oriented for use with the display when the coin is either not, or barely, visible.

C. SUPPORTING DIAGRAMS
1. Figure 20, EDB Circuit Diagram.
2. Figure 21, Ultrasonic Ranging System Timing Diagram.
3. Figure 22, EDB Component Layout and Printed Circuit Board.
LC is the reference.
LE min. is the earliest echo received, .9 feet (1.6ms).
LE max. is the furthest echo received 35.0 feet (62.2ms).
OF is 177.6ms from LC.

FIGURE 21. TIMING DIAGRAM-ULTRASONIC RANGING SYSTEM
IV—TECHNICAL SPECS

A. ELECTROSTATIC TRANSDUCER—INSTRUMENT GRADE

General Description
This electrostatic transducer is specifically intended for operation in air at ultrasonic frequencies. The assembly comes complete with a perforated protective cover.

Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usable Transmitting Frequency Range</td>
<td>See Graph</td>
</tr>
<tr>
<td>Usable Receiving Frequency Range</td>
<td>See Graph</td>
</tr>
<tr>
<td>Beam Pattern</td>
<td>See Graph</td>
</tr>
<tr>
<td>Minimum Transmitting Sensitivity at 50 kHz</td>
<td>110 dB</td>
</tr>
<tr>
<td>300 vac pk-pk, 150 vdc bias (dB re 20 μPa at 1 meter)</td>
<td></td>
</tr>
<tr>
<td>Minimum Receiving Sensitivity at 50 KHz</td>
<td>- 42 dB</td>
</tr>
<tr>
<td>150 vdc bias (dB re 1 v/Pa)</td>
<td></td>
</tr>
<tr>
<td>Suggested DC Bias Voltage</td>
<td>150 V</td>
</tr>
<tr>
<td>Suggest AC Driving Voltage (peak)</td>
<td>150 V</td>
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<tr>
<td>Maximum Combined Voltage</td>
<td>400 V</td>
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<tr>
<td>Capacitance at 1 kHz (Typical)</td>
<td>330-410 pf</td>
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<td>150 vdc bias</td>
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<td>Operating Conditions (Typical)</td>
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<td>Relative Humidity</td>
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<td>Standard Finish</td>
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<tr>
<td>Foil</td>
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<tr>
<td>Housing</td>
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</table>

Specifications subject to change without notice
NOTE: These curves are representative only. Individual responses may differ.

TYPICAL TRANSMIT RESPONSE

TYPICAL FREE FIELD RECEIVE RESPONSE

TYPICAL BEAM PATTERN AT 90 kHz

Note: dB normalized to on-axix response
IV—TECHNICAL SPECS

B. ELECTROSTATIC TRANSDUCER—COMMERCIAL GRADE

General Description
This electrostatic transducer is specifically intended for operation in air at ultrasonic frequencies. The assembly comes complete with a perforated protective cover.

Specifications

Usable Transmitting Frequency Range

Usable Receiving Frequency Range

Beam Pattern

Minimum Transmitting Sensitivity at 50 kHz
300 vac pk-pk, 150 vdc bias
(dB re 20 μPa at 1 meter)

Minimum Receiving Sensitivity at 50 KHz
150 vdc bias (dB re 1 v/Pa)

Suggested DC Bias Voltage
150 V

Suggest AC Driving Voltage (peak)
150 V

Maximum Combined Voltage
400 V

Capacitance at 1 kHz (Typical)
150 vdc bias
350-450 pf

Operating Conditions (Typical)
Temperature
32° - 140 ° F
Relative Humidity
5%-95%

Standard Finish
Gold
Foil
Flat Black

Specifications subject to change without notice
NOTE: These curves are representative only. Individual responses may differ.

TYPICAL TRANSMIT RESPONSE

TYPICAL FREE FIELD RECEIVE RESPONSE

TYPICAL BEAM PATTERN AT 50 kHz

Note: dB normalized to on-axis response
POLAROID ULTRASONIC RANGING SYSTEM
Four Frequency Board

Unmodified Ranging Circuit Board #606191
Modified Ranging Circuit Board #606745

TECHNICAL DATA

General Description:
The ranging module contains all necessary components to: generate the drive signal for the transducer; control timing functions; receive, amplify and filter the returned echo; and process this signal providing a step function output at the time of the received echo. The distance from the transducer to the target can then be computed with additional circuitry, knowing the speed of sound in air (or other gas), and the time interval between the transmit signal and the received echo as provided by the ranging module.

The #606745 board supplied with the designer’s kit consists of a #606191 board which has had a six-wire, ribbon cable attached and has been modified. The #606745 board does not have the transducer cable attached; however, this cable can be purchased from Polaroid by requesting Cable Assembly #604789.

Features:
Measurement range of 0.9 feet to 35 feet
Nominal resolution ± 0.12 inches to 10 feet
± 1% over entire range
Multiple measurement capability
Drives Polaroid Electrostatic Transducer which requires 50 kHz, 300V signal with no additional interface.

Designed to operate with the Polaroid Instrument Grade Electrostatic Transducer #604142.

Operating Conditions:

Supply Voltage 5.0 Vdc
Continuous Operating Current 250 mAmp
Peak Current During Transmit 2.5 Amp
Temperature Range 0 to 40 Deg C.

Signal Description:

<table>
<thead>
<tr>
<th>NAME</th>
<th>DESCRIPTION</th>
<th>WIRE COLOR On #606745</th>
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</thead>
<tbody>
<tr>
<td>VCC</td>
<td>Positive, Power Supply</td>
<td>Yellow &amp; Orange</td>
</tr>
<tr>
<td>VSW</td>
<td>Starts a transmit/receive cycle when taken high</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resets for next cycle when taken low</td>
<td>Red</td>
</tr>
<tr>
<td>XLG</td>
<td>Transmit detect, use first rising edge after VSW high</td>
<td>Blue</td>
</tr>
<tr>
<td>FLG</td>
<td>Receiver detect, goes high when an echo is detected</td>
<td>Green</td>
</tr>
<tr>
<td>GND</td>
<td>Ground, Power Supply</td>
<td>Brown</td>
</tr>
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<td>XDUCER</td>
<td>Transducer Input</td>
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<td>Transducer ground</td>
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Electrical Characteristic:

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<td>2.0</td>
<td></td>
<td></td>
<td>Vcc</td>
</tr>
<tr>
<td>Vol</td>
<td></td>
<td></td>
<td>0.8</td>
<td>Vdc</td>
</tr>
<tr>
<td>ioi</td>
<td></td>
<td></td>
<td>1.0</td>
<td>mA</td>
</tr>
</tbody>
</table>

Unmodified Ranging Circuit Board #606191
Modified Ranging Circuit Board #606745

Dimensions

SIZE: MAX DIM.
3.025 IN. X 1.652 IN.
X 0.520 IN.

Application Notes:

The ranging modules #606191 and #606745 are designed to function with the Polaroid Instrument Grade Transducer #604142.

Power the module through VCC. Next bring VSW high. The transmit burst of 56 pulses will begin approximately 5 mSec later. The 56 pulses consist of 8 cycles at 60 kHz, 8 cycles at 56 kHz, 16 cycles at 52.5 kHz and 24 cycles at 49.4 kHz and lasts for a period of about 1.0 mSec. Detected transmit can be observed at U2-12. The receiver is blanked for 1.6 mSec. If an echo is not detected within 62.5 mSec, FLG will go high. Also if an echo is detected before 62.5 mSec, and after 1.6 mSec, FLG will go high.

Range information is determined by the time interval between the first rising edge of XLG and the rising edge of FLG. The speed of sound in air is:

\[ C = 331.4 \sqrt{\frac{T}{273}} \] M/Sec

\[ C = \text{Speed of sound in air} \]
\[ T = \text{Temperature in degree Kelvin} \]
\[ (\text{Kelvin} = \text{Celsius} + 273) \]
\[ M = \text{Meters} \]
\[ \text{Sec} = \text{Seconds} \]

To initiate another range measurement, bring VSW low then high again while leaving VCC on.

The system (transducer and ranging module) gain is set to detect a 1.34 inch diameter sphere at 4 feet 3 inches on the acoustic axis.

If the ranging circuit board contains R6, adjustments are not recommended. R6 can change system gain and will change these specifications. If R6 is needed, refer to the parts list for installation, location and specification. C2 will have to be relocated to the unused pad connected to the R6 wiper.
Existing Ranging Circuit Board Alterations

The Ultrasonic Circuit Board (#606745), included with the Ultrasonic Designer's Kit, has been modified for use in ranging applications. Module #606191, ordered separately, will have to be modified by the purchaser to achieve the same performance. Other changes could be necessary for a particular application. Refer to the figure below to see how the ranging module #606191 must be altered to obtain performance similar to that of module #606745 in the kit (modified module #606745 is also available). Make the alterations as follows:

A. Cut the metallic circuit path on the board at the two points indicated by the arrows. Scrape the metal away or use any other effective method.
B. Solder 1 jumper wire to the board as shown: between points A and A'.
C. Cut switch as shown below.
POLAROID ULTRASONIC RANGING SYSTEM

Single Frequency Board

Unmodified Ranging Circuit Board #606192
Modified Ranging Circuit Board #607089

General Description:
The modified ranging module contains all necessary components to: generate the drive signal for the transducer; control timing functions; receive, amplify and filter the returned echo; and process this signal providing a step function output at the time of the received echo. The distance from the transducer to the target can then be computed with additional circuitry, knowing the speed of sound in air (or other gas), and the time interval between the transmit signal and the received echo as provided by the ranging module. The unmodified ranging board requires the addition of two transistors and two resistors before it can be used to drive a transducer. These can either be added to the ranging board or included with your electronics. Further details are shown on the following page.

The #607089 board supplied with the designer’s kit consists of a #606192 board which has had an output circuit added, a six-wire, ribbon cable attached and has been modified. The #607089 board does not have the transducer cable attached; however, this cable can be purchased from Polaroid by requesting Cable Assembly #604789.

Features:
Measurement range of 0.9 feet to 35 feet
Nominal resolution ± 0.12 inches to 10 feet
± 1% over entire range

Multiple measurement capability
Drives Polaroid Electrostatic Transducer, which requires 50 kHz 300V signal, with addition of parts shown on schematic below.

Designed to operate with the Polaroid Instrument Grade Electrostatic Transducer #604142.

Operating Conditions:
Supply Voltage 5.0 Vdc
Continuous Operating Current 250 mAmp
Peak Current During Transmit 2.5 Amp
Temperature Range 0 to 40 Deg C.

Schematic:

N = Pin Numbers on U3 Position
Q1A = 2N4401 or Equiv.
Q2A = MPS-A14 (Motorola)
Interconnect Diagram:

NOTE: Color Codes are for the ribbon cable supplied with #607089
Modified Ranging Circuit Board

NOTE: See Page 7.
Modified Single Frequency Ranging Circuit Board #607089

Parts List:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>REF.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R10</td>
<td>RESISTOR (22K, 5%, ¼W)</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>P.C. BOARD</td>
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<tr>
<td>3</td>
<td>Q1A</td>
<td>TRANSISTOR 2N-4401</td>
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<tr>
<td>4</td>
<td>C3</td>
<td>CAPACITOR 1µf, 35V</td>
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<tr>
<td>5</td>
<td>R9</td>
<td>RES. 150 Ω</td>
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<tr>
<td>6</td>
<td>U2</td>
<td>DIGITAL IC</td>
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<tr>
<td>7</td>
<td>C4</td>
<td>CAPACITOR .001µf, 10V</td>
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<td>8</td>
<td>U1</td>
<td>ANALOG IC</td>
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<tr>
<td>9</td>
<td>C1</td>
<td>CAPACITOR .01µf, 10V</td>
</tr>
<tr>
<td>10</td>
<td>L1</td>
<td>TUNED CIRCUIT INDuctor</td>
</tr>
<tr>
<td>11</td>
<td>C2</td>
<td>CAPACITOR .01µf, 10V</td>
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<tr>
<td>12</td>
<td>R4</td>
<td>RESISTOR (62K, 5%, ¼W)</td>
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<tr>
<td>13</td>
<td>R6</td>
<td>VARIABLE RESISTOR (25K, ¼W) (see note 2)</td>
</tr>
<tr>
<td>14</td>
<td>C5</td>
<td>CAPACITOR .001µf, 400V</td>
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<tr>
<td>15</td>
<td>T1</td>
<td>TRANSFORMER</td>
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<tr>
<td>16</td>
<td>R1</td>
<td>RESISTOR (1-10K, 5%, ¼W) (see note 1)</td>
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<tr>
<td>17</td>
<td>CR1</td>
<td>DIODE ZENER (IN4006)</td>
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<td>18</td>
<td>CR2</td>
<td>DIODE ZENER (IN4006)</td>
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<td>19</td>
<td>R2</td>
<td>RESISTOR (130K, 5%, ¼W)</td>
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<td>C10</td>
<td>CAPACITOR .01µf, 10V (see note 2)</td>
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<td>21</td>
<td>XTAL</td>
<td>CRYSTAL 420 kHz</td>
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<tr>
<td>22</td>
<td>Q2A</td>
<td>TRANSISTOR MPS-A14 MOTOROLA</td>
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<tr>
<td>23</td>
<td>R11</td>
<td>RESISTOR (2.2K, 5%, ¼W)</td>
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</tbody>
</table>

NOTE: 1. Resistor Value Set at Factory
NOTE: 2. Optional, Some Boards Do Not Contain R6 or C10
Application Notes:
The ranging modules #606192 and #607089 are designed to function with the Polaroid Instrument Grade Transducer #604142.

Power the module through VCC. Next bring VSW high. The transmit burst of 56 pulses will begin approximately 5 msec later. The 56 pulses are at 49.41 kHz and last for a period of about 1.0 msec. Detected transmit can be observed at U2-12. The receiver is blanked for 1.6 msec. If an echo is not detected within 62.5 msec FLG will go high. Also if an echo is detected before 62.5 msec and after 1.6 msec, FLG will go high (See Application Notes, for four-frequency board).

Modifications:
The single frequency boards #606192 and #607089 are supplied in a form that can be trimmed to fit into smaller space constraints. Several components which are not used in ranging operations have been removed from the board. In response to customer requests, we have also left off the interface chip U3. This allows substitution of two transistors and two resistors which will permit a faster repetition rate without overheating. These can be included either on the ranging board in the space formerly occupied by U3, as we have done with #607089, or on a companion board, which will contain your other electronics. A wire cable must also be connected to #606192.

Modifications to #606192:
1. Cut printed circuit trace leading from U-3 pin 10, near pin.
2. Solder bridge between U-3 pin 8 to printed circuit trace leading to U-3 pin 14.
3. Install 2N-4401 transistor (Q1A) in U-3 location; emitter at pin 9, base at pin 10, collector at pin 11. Solder and trim all leads, but do not trim base (pin 10) and collector (pin 11) leads.
4. Install MPS-A14 transistor in U-3 location; emitter at pin 16, base at pin 15 and collector at pin 14. Solder and trim all leads, but do not trim base (pin 15) lead.
5. Install a 22K ohm resistor on the bottom of the board from Q1A base lead (pin 10) to U-3 location, pin 7. Solder and trim except do not trim lead at pin 7.
6. Install a 2.2K ohm resistor on the bottom of the board. Push one lead through U-3, pin 6, then bend it on top of the board and reinsert it in pin 3 to form a jumper between 6 and 3. The other lead attaches to both collector of Q1A at pin 11 and base of Q2A at pin 15. Solder and trim all leads, except do not trim pin 6.

7. Dress all leads to prevent contact with PC board traces.

8. Move 1.0 mfd tantalum capacitor from location at unused end of board to position above right of U-3 (see print).

9. Connect a 5 wire cable as described below (see print).*

---

Brown (GND) to pad 9
Red (VSW) to pad 7
Orange (and yellow optional) (VCC) to U-3 pin 6 (lead from 2.2K resistor) NOTE: Trim lead after attaching orange wire. An alternate location is at empty R7 hole (see print).
Green (FLG) to U-3 pin 4
Blue (XLG) to U-3 pin 7 (lead from 22k resistor) NOTE: Trim lead after attaching blue wire

---

*6 Wire cable, as used with modified board #606745, has yellow and orange wires both connecting to VCC.

---

Polaroid Corporation Commercial Battery Division Product List OEM

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th>Minimum Quantity</th>
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<tbody>
<tr>
<td></td>
<td><strong>Ultrasonic Ranging:</strong></td>
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<tr>
<td>603972</td>
<td>Ultrasonic Ranging Designer’s Kit</td>
<td>1</td>
</tr>
<tr>
<td>606783</td>
<td>OEM Kit (2 Transducers &amp; 2 Ranging Boards)</td>
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<tr>
<td>604142</td>
<td>Transducer, Instrument Grade</td>
<td>10</td>
</tr>
<tr>
<td>604029</td>
<td>Transducer, Commercial Grade</td>
<td>10</td>
</tr>
<tr>
<td>604789</td>
<td>Cable Assembly</td>
<td>100</td>
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<tr>
<td>605540*</td>
<td>Coil for Ranging Board</td>
<td>10</td>
</tr>
<tr>
<td>605541*</td>
<td>Transformer for Ranging Board</td>
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</tr>
<tr>
<td>605794</td>
<td>Transducer, Intrinsically Safe U/L recognized</td>
<td>10</td>
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<tr>
<td>606191</td>
<td>Unmodified Four Frequency Ranging Board</td>
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<tr>
<td>606192</td>
<td>Unmodified Single Frequency Ranging Board</td>
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<tr>
<td>606745</td>
<td>Modified Four Frequency Ranging Board</td>
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<td>607089</td>
<td>Modified Single Frequency Ranging Board</td>
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<tr>
<td>606199</td>
<td>Unmodified Limited Range Board</td>
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<tr>
<td>606918*</td>
<td>Designer’s Kit manual</td>
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|        | **Battery Products:**                            |                  |
| 604155*| P100 Battery Designer’s Kit                     | 1                |
| 606166*| P500 Lithium Battery Designer’s Kit             | 1                |
| 604152 | P100 Battery                                    | 100              |
| 605586 | P500 Battery                                    | 100              |
| 604477 | Nonreplaceable P100 Battery                     | 100              |
| 605756 | Nonreplaceable P80 High Power Battery           | 100              |
| 606014 | Nonreplaceable P743 Smaller Size Battery        | 100              |
| 604145 | Single Battery Holder                           | 10               |
| 604398 | Dual Battery Holder                             | 10               |
| 604148 | Battery Contacts                                | 200              |

NOTE: Minimum order $50.00 except * items.
## SUMMARY DATA POLAROID BATTERIES - 6 VOLT

<table>
<thead>
<tr>
<th>Battery Number</th>
<th>Size (Inches)</th>
<th>Weight (Ounces)</th>
<th>Type (1)</th>
<th>Capacity In Milliamp-Hours At Constant Drain</th>
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<tbody>
<tr>
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<td></td>
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<td>1mA</td>
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<tr>
<td>P743</td>
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<td>P100</td>
<td>3.73x3.04x0.18</td>
<td>0.95</td>
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<td>P80</td>
<td>3.23x2.73x0.20</td>
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<td>1.2</td>
<td>LM-R</td>
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(1) ZM = Zinc Manganese dioxide - 3 year shelf life  
LM = Lithium-Manganese dioxide - over 5 year shelf life anticipated  
N = Non-Replaceable by consumer - OEM only  
R = Available in retail outlets for consumer replacement

**NOTE:** A dash means test not done at that drain; not limit of battery use.  
All batteries are useful at nanoamp drains.