BUILD A MICRO TV TRANSMITTER

This wireless mini video transmitter sends a picture to your TV set. It's ideal for security monitoring or observing nature.

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THE MINIATURE SINGLE-BOARD VIDEO camera used in this project is an excellent example of how recent advances in integrated circuit and surface-mount technology have led to remarkable advances in video technologies. A complete, reasonably priced solid-state camera will easily fit in the palm of your hand.

This article describes how you can build a simple modulator/transmitter and connect it to a commercially available video camera to obtain a portable, battery-operated camera that can transmit black and white pictures from remote locations back to your TV set. No antenna is needed to transmit to a nearby TV set, but if an external antenna is used, the modulator has enough power to transmit about 100 yards. The RF modulator/transmitter can transmit over standard NTSC channels 7 to 13 or UHF channels 14 to 29.

The mini video camera on which this project is based measures 0.91 × 1.81 × 2.76 inches and it weighs only 1.3 ounces. The camera requires a 6- to 12-volt DC power supply, and draws a current of only 65 milliamperes.

The applications for a battery powered, hand held TV transmitter are limited only by your imagination. Home or business security come most readily to mind. Because cables are unnecessary, there is no danger of an intruder cutting cables and disabling the camera. The camera can be placed in an unobtrusive location protected from the weather.

You can also use this camera transmitter to keep an eye on an infant in a crib or observe a disabled or bedridden person. And you could also put this camera to work as the "eyes" of a robot or for monitoring industrial welding or machining operations that would pose a safety threat to people standing too close.

If you are a farmer, you can monitor the behavior of livestock in a barn, and if you're a nature hobbyist, you can observe wild animals and birds at close range. The ability of the camera to "observe" action in reduced light will be particularly attractive.

The camera/transmitter system can be powered from an AC to DC wall-mounted adapter, or it can be powered from a standard 9-volt battery. The service life of an alkaline-manganese battery is approximately four hours.

Camera modules with several different configurations are available from the source given in the parts list. One is a super wide-angle (110° field-of-view) 3-mm, *f*1.8 lens; the other is a narrower angle (78° field-of-view) 4.3-mm, *f*1.8 lens. A 12-mm, *f*1.8 lens is available for those interested in aerial or nature photography. This camera, when placed behind the viewfinder of a single-lens reflex (SLR) still camera, will accept the full field-of-view of the still camera lens and permit remote

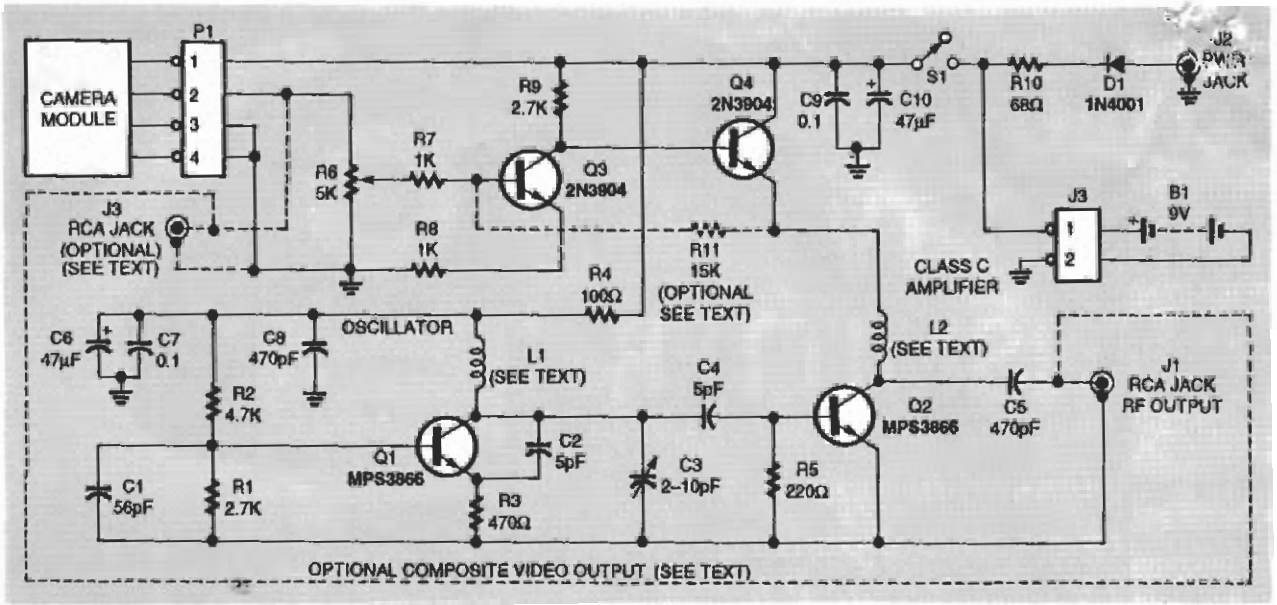


FIG. 1—MODULATOR SCHEMATIC. Coil L1 is the key component that determines the frequency of oscillation.

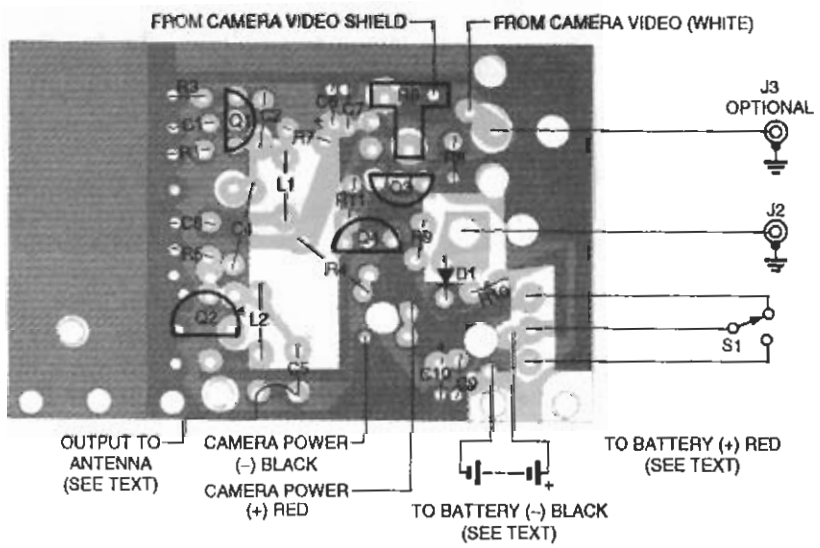
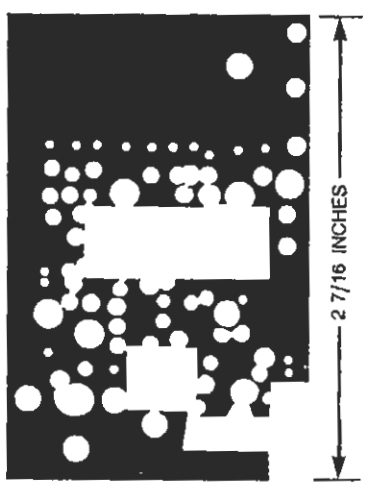
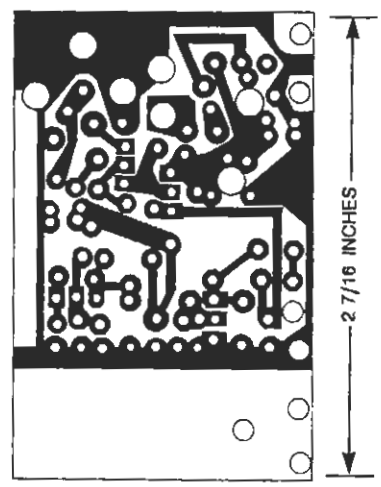


FIG. 2—PARTS-PLACEMENT DIAGRAM. Note that the board can be cut, if needed, to fit in a smaller case.



SOLDER SIDE of the board.



COMPONENT SIDE of the board.

monitoring of the picture to be taken.

The CCD mini camera is also sensitive to infrared (IR) radiation, and when paired with a simple infrared light source, can be used to see in the dark. For robotic or industrial applications, a single infrared-emitting LED emits enough energy to illuminate nearby objects.

The modulator is built on a 2¼ × 1½-inch printed-circuit board, which is mounted on insulating standoffs above the camera module. A wiring harness and plug connect the camera to the modulator.

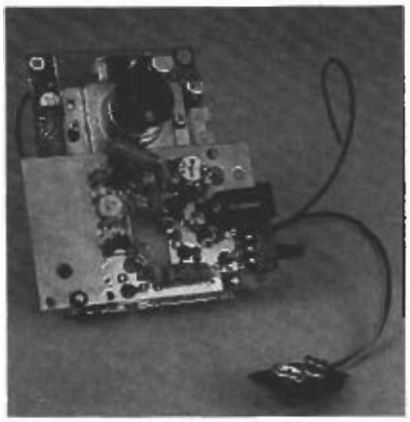
Modulator operation

The schematic of the transmitter is shown in Fig. 1. The circuit operates as follows: Transistor Q1 is the amplifier in a transistor oscillator that oscillates in the frequency range of VHF channels 7 to 13 (174 to 216 MHz) or slightly above (250 MHz), depending on the desired transmitter frequency. The output from the resonant tank circuit of the oscillator, formed by coil L1 and capacitor C3, is capacitively coupled by C4 to the base of the Class-C amplifier stage that includes Q2.

The combination of L2 and the parasitic capacitance of the PC board broadly tunes the output of Q2 to either the same range of frequencies as the os-

cillator stage, or to a frequency that is twice that of the oscillator stage, which permits the transmitter to cover Channels 14 to 29 (470 to 580 MHz).

The Class C amplifier stage is collector-modulated by a two-transistor modulator that consists of Q3 and Q4. The output from the camera is directly coupled to Q3 through variable resistor R6. The ratio of resistors R9 and R8 in the collector and emitter circuits of Q3 determines the gain of approximately three for this stage. The output of the camera is an NTSC composite video signal of approximately 2 volts peak-to-peak amplitude with a 0.7 volt DC offset. The output of Q3 is directly coupled to emitter follower Q4, which collector-modulates the Class C output stage.



THE MODULATOR BOARD after being mounted on the video camera module.

The modulator has been designed to work primarily with the camera described, but it can also be used as a modulator for any composite video device. This is accomplished by changing the value of R9 from 2700 ohms to 4700 ohms, thus increasing the gain of the input stage and adding 15 K resistor R11, which removes the DC offset from the amplifier stage. Provision has been made on the modulator printed circuit board to add an optional right-angled RCA connector that can provide baseband video output or accept baseband video input when the modulator is used with other devices.

Diode D1 and resistor R10 form a simple battery-charger circuit. Diode D1 also protects the camera from reverse voltage should a charger with the wrong polarity be connected accidentally.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise specified.
R1, R9—2700 ohms (see text)
R2—4700 ohms
R3—470 ohms
R4—100 ohms
R5—220 ohms
R6—5000 ohms, potentiometer
R7, R8—1000 ohms
R10—68 ohms
R11—15,000 ohms (see text)

Capacitors
C1—56 pF, ceramic disk
C2, C4—5 pF, ceramic disk
C3—2 to 10 pF trimmer
C5, C8—470 pF, ceramic disk
C6, C10—47 µF, 16 volts, aluminum electrolytic
C7, C9—0.1µF, ceramic disk

Semiconductors
Q1, Q2—MPS3866 NPN transistor
Q3, Q4—2N3904 NPN transistor
D1—1N4001 rectifier diode

Other components
L1—3 turns tinned bus wire wound on a 3/16-inch drill bit for channels 7–13 OR 2 turns tinned bus wire wound on a 3/16-inch drill bit for channels 14–29 (see text)
L2—Same as L1 (see above)
J1—Bulkhead-mounted RCA jack (optional)
J2—2.1 mm DC power jack
J3—right-angle RCA jack (optional)
S1—SPDT miniature switch
Miscellaneous: CCD Camera Module (Chinon CX-102), PC Board, plastic case, 9-volt alkaline battery, hardware, 5/16-inch nylon standoffs, ½-inch No. 2-56 screws and nuts, coaxial cable, wire, solder.

Note: The following items are available from Bayview Hobby Supplies, 14800 Yonge St. #110, Aurora, Ontario, Canada L4G 1N3. Tel: (416) 713-0528. Fax: (416) 841-4436:
- **Camera module including wiring harness—$229.00 (specify Model M100W with wide angle 3 mm lens and 110 degree field of view or Model M100N normal angle 4.3 mm lens and 78 degree field of view)**
- **Modulator PC board (M200)—$12.95**
- **Drilled plastic case (M201)—$14.95**
- **9-volt AC wall adapter (M202)—$14.95**
- **Modulator kit (M300)—$49.95**
- **Completed modulator (M301)—$99.95**
- **Kit including camera module, all parts, hardware, and case (M400)—$299.00**
- **Semi-kit, includes camera module and fully assembled and tested modulator board (M401)—$329.00**
- **Completely assembled and tested camera and modulator mounted in case (M402)—$349.00**

All prices in U.S. funds.

Construction

A complete modulator circuit board can be purchased from the source given in the parts list. However, foil patterns are provided for those who want to make their own. Note that the circuit board stock is 0.031-inch thick glass-epoxy with copper foil on both sides. (Paper-based PC boards should not be used at the high frequencies produced in this circuit).

Certain parts of the ground-plane foil on the component side of the board must be removed to provide insulated surfaces for some components. See the parts-placement diagram in Fig. 2.

Mount all components on the non-solder ground-plane side of the board. Mount all resistors vertically after forming the leads. Mount all disc capacitors as close as possible to the ground plane. Both electrolytic capacitors are mounted horizontally and their axes lie parallel to the surface of the board.

Begin by mounting the shortest components first. Start first with the variable capacitors, variable resistor, and the ceramic disc capacitors. Then add the transistors, resistors, and coils.

Although there are no critical component positioning requirements, take special care when installing the transistors. They look alike, but the circuit will not work if they are acciden-

tally interchanged. Capacitor C8 is an RF bypass capacitor that forms part of the tank circuit. Its leads should be as short as possible.

Coil L1 is a 2- or 3-turn coil (depending on the output frequency selected) of No. 22 AWG tinned wire wound on an 3/16-inch drill bit. The coil, in conjunction with variable-capacitor C4, determines the oscillator frequency. This frequency is in the range of 174 to 216 MHz for channels 7 to 13, or 235 to 280 MHz for channels 14 to 29. (The oscillator frequency is doubled to 470 to 560 MHz in the Class C stage for the higher channels). Diode D1 should be mounted with its anode closest to power jack J2.

After all components are soldered, install the battery clip, wiring, and plug for the TV camera module. These wires enter from a hole in the bottom of the board to provide strain relief, and they are soldered after insertion into holes in the top of the board. The modulator can be operated without an antenna but, if longer range is desired, an antenna can be connected to output capacitor C5 (see options section).

Alignment

When the board components have been assembled and soldered, check the current drain with the modulator connected to a 9-volt supply. The current drain should be about 25 milliamperes, and should drop to about 10 milliamperes when the main oscillator is inhibited (which is accomplished by touching L1 with a finger.) This simple test indicates that the oscillator is functioning and the Class C stage is amplifying.

After testing, mount the finished modulator board above the camera module with two 5/16-inch long nylon standoffs and two ½-inch long No. 2-56 screws and nuts.

After mounting the modulator board, the camera plug can be connected. At this time, check the current drain again. With the camera connected, the drain from a 9-volt supply should be about 85 milliamps.

With a television receiver tuned to the desired channel near the completed unit and power applied to the camera and modulator, tune C3 until a video image appears on the screen. Turn R6 clockwise to a position that gives a picture with maximum contrast and no "tearing."

If no video image appears on the screen after all other possible sources of assembly error have been eliminated, adjust L1 by separating its turns to raise the output frequency or compress the turns to lower the frequency. When using video sources other than the camera, it will be necessary to change R9 from 2.7K to 4.7K to increase the gain of the modulator. Also add the 15K resistor R11 to eliminate DC offset.

Once these adjustments are made, mount the completed unit in the plastic case and fasten the back in position with four self-tapping screws.

There is no voltage regulation to compensate for battery-voltage variation. The resistor values in the oscillator section have been selected so that the oscillator exhibits a minimum frequency shift over the usable battery range.

Options

Provision has been made in this design to offer the user a number of options to give the camera extra versatility.

- **Frequency.** The modulator is designed to operate either on Channels 7 to 13 or 14 to 29. For Channels 7 to 13, coils L1 and L2 are three turns of No. 22 wire wound on a 3/16-inch form. For Channels 14 to 29, coils L1 and L2 are *two* turns of No. 22 wire wound on a 3/16-inch form.
- **Enclosure.** You might want to mount the unit in its own enclosure such as a picture frame or lamp for surveillance. The modulator board can be mounted to the camera without modification, or it can be cut with shears along line A-A to make it smaller.
- **RCA Input/Output Jack.** Provision has been made on the PC board for a right-angle RCA jack. (Note that the board will not fit in the case pictured if this option is selected.) This option provides composite baseband output from the RCA jack, or composite video can be introduced to the jack from an external source.
- **Wall Adapter.** The camera unit can be powered from any negative ground (positive tip) 9-volt wall adapter. When a wall adapter is used, the battery should be removed. Be sure that the output of the adapter does not exceed 12 volts.
- **Rechargeable Battery.** A rechargeable nickel-cadmium battery can replace the suggested alkaline battery, although battery life will only be about half as long (two hours instead of four hours) before the battery needs a recharge. Resistor R10 has been selected to recharge the battery in approximately four hours. Many rechargeable 9-volt batteries actually have terminal voltages of 7.2 volts and will charge at a higher rate. Most wall-mounted chargers are poorly regulated and their voltage rises dramatically when lightly loaded. Make sure that the battery does not overcharge.
- **RF and Baseband Output.** For short range use (up to 30 feet), no antenna is necessary as long as there is an adequate antenna on the TV receiver. For longer range, a 1 foot length of No. 18 stranded copper hookup wire can be connected to output capacitor C5 and extended through the case. If you want both baseband output and RF output, an optional RCA jack can be mounted on the front panel of the case and the output from C5 can be connected to it by a short length of wire.

A length of coaxial cable from the camera harness can be connected from the jack to the camera output on the modulator board. (The cable effectively blocks RF from getting back into the camera.)

If you want baseband output, an RCA plug and cable inserted into the jack will provide composite video output to a video monitor. If you want RF output, an antenna can be inserted into the RCA jack. Ω