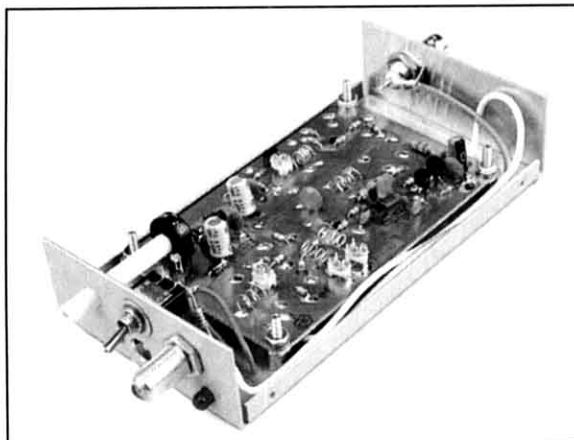


By William Sheets, K2MQJ and Rudolf F. Graf, KA2CWL

Get on 440-MHz ATV!



Part 1: A Tunable Downconverter

ATV isn't a new mode of communication, but it may be to you. Years ago, getting on ATV was an expensive proposition, but that's not true any longer. Some of the equipment needed (a TV/monitor, VCR and video camera) is already part of the lifestyle of many nonhams as well as hams. With the addition of an easily built downconverter, transmitter and some ancillary hardware, you can be both *seen* and *heard*! In this three-part series, we'll describe the gear you need and show you how to hook it together. We'll start with the downconverter.

What's on TV?

If you're thinking of getting on 70-cm ATV, the first thing you'll probably want to do is see what sort of activity there is on the band. To watch 70-cm ATV signals on a standard VHF TV receiver or monitor, you need a downconverter. This one converts TV or other wideband signals in the 420 to 440-MHz (70-cm amateur TV) range to a 61.25 or 67.25-MHz IF output (TV channel 3 or 4). The converter is stable and sensitive, has a 1 to 1.5-dB noise figure (NF) and costs about \$40 if all new parts are purchased and a homebrew PC board is used. Components and boards are available.¹

Some cable-ready TV sets cover frequencies in the 70-cm range, but most new sets have frequency synthesized tuners and aren't capable of receiving the frequencies in between the 6-MHz CATV channels. Also, for best weak-signal reception, you generally need a preamplifier with these sets, so you need an outboard device anyway. For these reasons, a tunable converter may be the best way to go.

General Description

See Figure 1. The five-transistor circuit

consists of a low-noise RF amplifier, a mixer, a tunable local oscillator (LO) and a feedback-pair IF preamplifier stage. The RF amplifier is a low-noise, dual-gate MESFET followed by a UHF bipolar transistor mixer. The LO is voltage-tuned by a potentiometer, or remotely via a coax-fed dc-tuning and supply voltage connected to the **IF OUTPUT** jack. Remote-tuning circuitry is on board for coax dc and IF feed. This enables you to mast-mount the converter to reduce feed-line losses. The converter's input impedance is 50 Ω , and any suitable 70-cm antenna can be used with it. For portable operation—or for use in a packaged ATV transceiver or a video H-T—the on-board tuning potentiometer comes in handy. Power supply requirements are 11 to 20 V dc at approximately 30 mA.

Overall converter gain is nominally 37 to 43 dB (the gain is adjustable) with an RF bandwidth and tuning range greater than 20 MHz for 420 to 440-MHz operation. Because the converter uses a tunable LO covering 20 MHz with a shaft rotation of 270°, it's primarily intended for reception of wideband modes such as ATV, *not* narrowband FM or SSB signals.

The converter can be aligned simply by peaking for maximum received signal; no tricky alignment procedure or specialized RF test gear is needed for good results. You can place the IF anywhere between 40 and 100 MHz by changing *one* component and shifting the LO frequency.

Circuit Description

Refer to Figure 1. A signal from the antenna jack, J1, is fed to L4 and C1. C1 is adjusted for best reception of a weak signal. The signal is applied to the gate of Q1, a low-noise MESFET with a noise figure (NF) of around 1 dB. Unavoidable circuit losses raise the actual NF to 1.4 dB typically, which is fairly good for the intended application. Chip capacitors (C2 through

C5) bypass Q1's source and gate 2. (Conventional disc capacitors are not as effective as chip capacitors at UHF.)

The amplified signal at the drain of Q1 is fed to a double-tuned network: L5, C8, C34, L6, and C9. RF stage gain is about 18 to 20 dB, including the losses in the tuned-circuit networks between the antenna input and the mixer input.

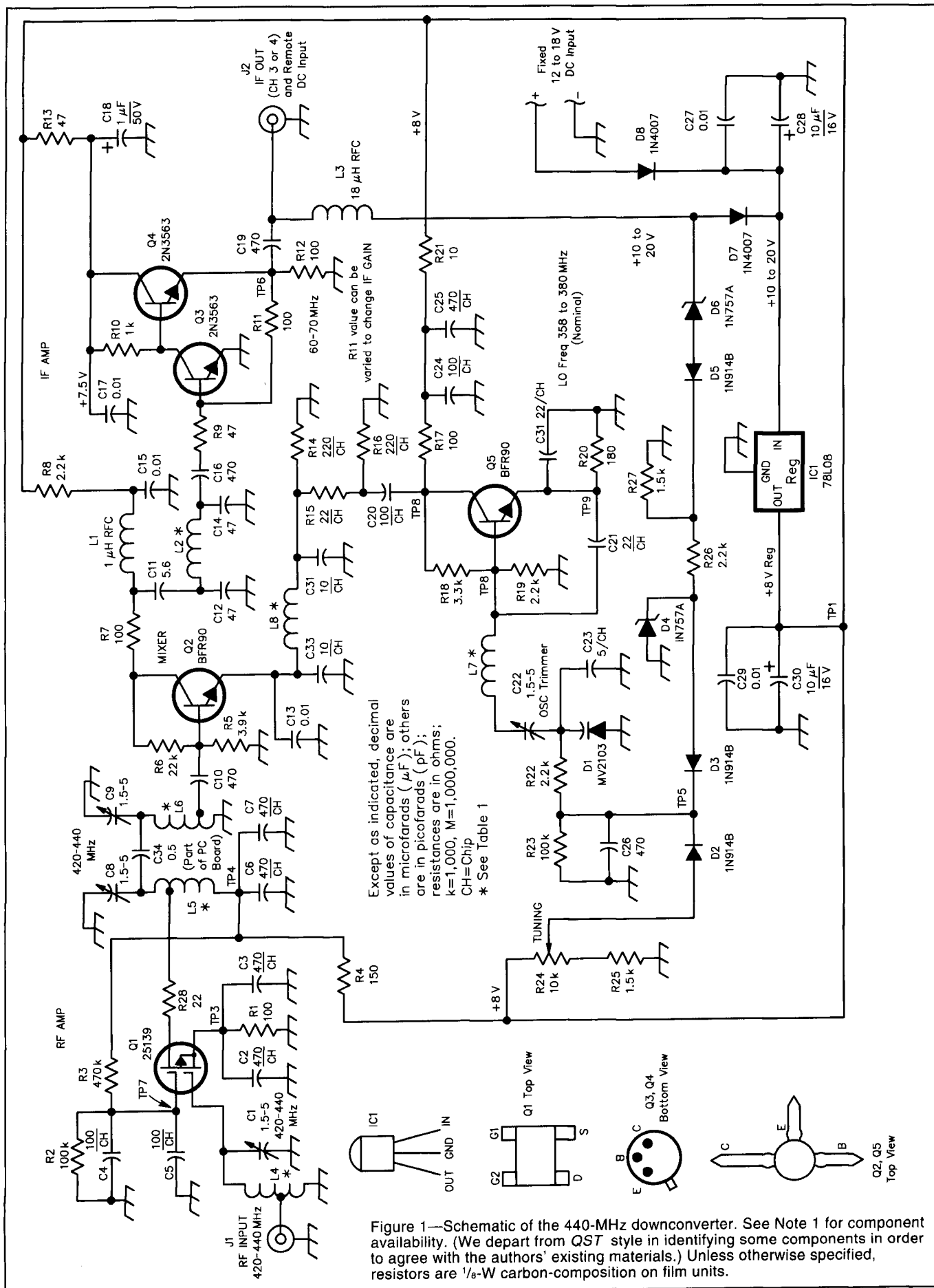
Q2, a BFR90, serves as a mixer. Mixer current is typically 1 mA. RF is fed via C10 to the base of Q2. LO injection from Q5 is fed to Q2's emitter via C31, L8 and C33, and a resistive pad (R14, R15 and R16). The LO frequency is equal to the received signal *minus* the IF. Varactor D1 and C22 tune the LO. Mixer gain is typically 10 to 13 dB. Overall converter gain so far is typically 30 dB.

Next, the IF signal goes to a matching network consisting of C11, C12, L1, L2, and C14. This network acts as a low-pass filter and rejects mixer output products above 100 MHz. Overall IF gain is about 6 dB and can be adjusted by changing the value of R11. The IF amplifier directly feeds a 50 to 75- Ω load. Maximum converter IF output is around -2 dBm for 1 dB compression (150 to 200 mV into a 50 to 75- Ω load).

LO Q5 is a Colpitts oscillator. The oscillator's resonant circuit is composed of C21, the internal base-emitter capacitance of Q5, C31, the stray capacitance of the PC board, L7, C22 and varactor D1 in parallel with C23. D1's capacitance is varied by applying 1 to 8 V to it via R22. D2's bias determines its capacitance and the resonant frequency of the oscillator's tuned circuit. This provides *fine* tuning, the setting of C22 having the *major* effect on oscillator frequency. C22 changes the oscillator frequency about 100 MHz and is used to set the LO frequency so that D1 can tune the LO over the desired range (about 358 to 380 MHz).

D1's voltage is supplied through R22 by

¹Notes appear on page 40.



one of two sources. One source is the on-board tuning potentiometer (R24), which provides 1 to 8 V at its wiper. R25 sets the low limit around 1 V. D2 acts as half of a logical OR gate. The second voltage source for D1 is a tuning voltage derived from a remote-tuning setup connected to the **IF OUTPUT** jack.

A long feed line is often needed to connect the station equipment to the antenna. Coaxial cable losses are often high, especially at UHF. Mounting the downconverter and transmitter at the antenna minimizes such losses. Dc for the converter and the IF signal (at 60 to 70 MHz) can be carried several hundred feet with little loss by inexpensive RG-59 or RG-6 75- Ω CATV cable. A dc-blocking network (see Figure 2) allows placing power supply and variable tuning voltages on the feed line. This presents 10 to 20 V dc to the **IF OUTPUT** jack. C19 blocks the dc, but passes the IF signal from Q4. L3 passes dc, but because it has a very high impedance at 60 MHz, blocks the IF signal. The 10 to 20-V input is passed to IC1 via D7. IC1 supplies the +8 V to power the converter circuitry, regardless of input voltage. The input voltage is also supplied to Zener diode D6 and diode D5, dropping 9 V across these diodes, resulting in 1 to 11 V appearing across pull-down resistor R27.

R26 and D4 limit the voltage at the input of D3 to 1 to 9 V. This results in about 0.3 to 8.3 V across R23 and C26, which is fed to D1 via R22, providing the correct tuning-voltage range. Therefore, as the dc voltage on the IF cable varies from 10 to 20 V, the converter is powered and tuned over its frequency range. If operation from a fixed nominal dc source (11 to 15 V) is desired, the converter is powered via the dc input and blocking diode D8. In that case, tuning is done with the on-board tuning potentiometer, R24.

If remote tuning is used, R24 must be set to its extreme CCW position to obtain the full converter tuning range. The tuning voltage should be clean. The tuning sensitivity of the LO is around 2.5 MHz/V. Any hum or noise on the tuning voltage will modulate the LO, causing unwanted FM of the LO and IF signals. The FM may create hum bars in the received picture. Conventional NTSC AM TV signals are less susceptible to this than FM TV commonly used at 1300 MHz and higher, but hum shouldn't be tolerated. It's not difficult to build clean power supplies with the excellent regulator ICs available today.

Construction

If you make your own double-sided PC board, don't substitute parts or change the layout as the layout is critical. When assembling the board, use good lighting and a magnifier. The parts used are quite small, especially Q1 and the chip resistors and capacitors. All trimmer capacitors and grounded resistor leads are soldered *on both sides of board*. This is essential for

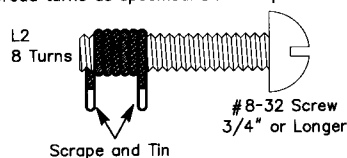
good RF grounding. There are 36 ground-plane jumpers. Plated-through holes would eliminate these, but then this PC board would not be reproducible by homebrewers. See Table 1 for coil-fabrication details.

Fit each component as close as possible to the board. First, install all the trimmer capacitors. Solder their rotor terminals to the PC board's top foil. Be careful not to

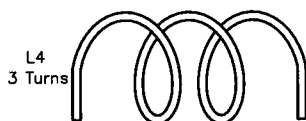
Table 1
Coil Data

All coils are wound with #22 wire. For L2, use *enameled* wire; L4 through L8 are wound with #22 bare tinned wire.

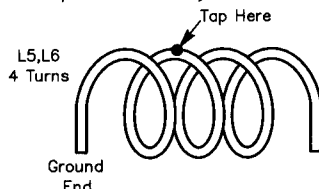
Wind all coils on a #8-32 Screw
Spread turns as specified. Do not spread L2 turns.



Space Turns evenly to fit PC Board

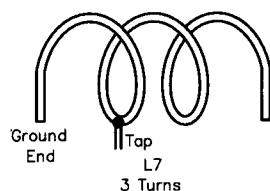


Space Turns evenly to fit PC Board



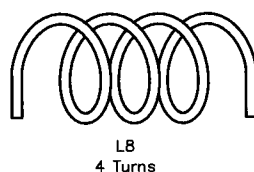
Tap for R28 on L5 at 1.5 Turns up from the Junction of L5, C6, C7 and R4
Tap for C10 on L6 at 1.5 Turns up from Ground End.

Space Turns evenly to fit PC Board



Tap at 1 Turn from Ground End for Antenna (Input) Connection

Space Turns evenly to fit PC Board



melt the trimmer's plastic parts. Don't solder the bottom-foil (groundplane) connections yet. Next, install all 1/8-W resistors. For now, solder the leads only to the top foil where they pass through the board. Chip resistors are mounted later. Install tuning potentiometer R24. Use a #8-32 screw as a tool to hold coils L2 and L4 through L8 during installation. After installing the coils, remove the screw. Coat L2 with clear lacquer, Duco cement or nail polish.

Using left-over lead clippings, install all groundplane jumpers—*this is very important!* Install all chip components on the bottom (groundplane) of the PC board. After installing the chip components, avoid flexing the PC board as this may crack the chip capacitors. Install Q1. (The thicker lead is the source.) Treat Q1 as gently as a chip capacitor and remember, it's static sensitive. Solder the trimmer capacitor rotor terminals and the resistor leads. Carefully inspect your work. Look for solder shorts, poor joints, missing parts, incorrect part placement, etc. Once you're sure everything's okay, you're ready for the tune-up procedure.

Tune-Up and Checkout

Successful tune-up of this converter requires a known signal in the 420 to 440-MHz band or access to a frequency counter and signal generator covering this range. If you have access to an ATV transmitter, you can use it as a signal source, but use a dummy antenna and keep it some distance from the converter to avoid overload. You'll need a suitable TV or monitor tuned to channel 3 or 4, a variable power supply providing 10 to 20 V dc at 40 mA or more (preferably with built-in metering), a VOM or DVM and clip leads and cables.

Connect a 12-V dc source to the power-supply input (D8 and ground). Ground is negative. (No damage to the converter will occur if the power-supply polarity is reversed.) Measure the current drawn from the supply. It should be around 35 mA, ± 5 mA. If the current drawn is more than 40 mA, check for a short circuit. If the current drawn is less than 30 mA, something may be open or missing. Make the following checks:

1. Refer to Figure 1 and make the voltage checks shown in Table 2. If you note discrepancies, check the identified components. Ignore slight variations from the specified voltages if component checks don't reveal anything wrong. However, if you experience trouble at a later step with that particular circuit, investigate further. Remember, the 8-V regulator has a 5% tolerance and this will affect other readings. Also, your VOM could be a few percent in error as well, especially if it's an older model.

2. Set R24 at its midpoint and mesh C22's plates about 75%. Measure the voltage at Q2's collector. Using a nonmetallic

Table 2
Voltage Test Points and Items to Check

(Note: Jct = junction)

Test Point	Voltage	Item to Check
D8, IC1	+11.4	D8
Jct IC1, C30 (TP1)	+ 8.0 ± 5%	Is IC1 in backwards?
Jct R4, C6, C7, L5 (TP4)	+6.2 to +7.2	Q1 installed correctly? R4, C6, C7
Jct R1, C2, C3 (TP3)	+0.5 to +1.2	Q1 installed correctly? R1, C2, C3
Jct R2, R3, C3, C4 (TP7)	+1.0 to +1.4	Q1, R2, R3, C4, C5
Q2 collector (TP2)	+5.5 to 7.2	Q2, R13-R16; R5-R8; L1, C11, C15, C17, C18
Jct D2, D3, C26 (TP5)	0.5 to >+7.0 as R24 is rotated	D1-D3; R24, R25, R22, R23
Q5 collector (TP8)	+6.5 to +7.2	R21, C24, C25, Q5, C20, R18-R20
Q4 emitter	+0.8 to +1.0	Q3, R10-R12; C16, C19
Q4 base	+0.7 more than Q3's base	Same as in previous step

tool, adjust C22. If Q5 is oscillating, you should see a perceptible change in the voltage reading as you adjust C22 from minimum to maximum capacitance and back. It's not possible to say exactly how much this change will be as it depends on many factors, but it should be readily perceptible on the meter. This checks out the LO circuit and confirms that the mixer is getting drive from the LO.

3. No components should be hot. If you experience some deviation in the voltage levels but the difference isn't great, all may still be okay, but mark this as suspect if you encounter any additional problems. If the following results are successful and the converter works well, ignore *minor* voltage variations; investigate *major* variations. Make sure that your test equipment is set properly.

4. If Steps 1 to 3 are successful, connect a variable-voltage supply to the junction of C19 and L3. Ensure that the wiper of R24 is at the ground end (extreme CCW as viewed from shaft side). Set the supply to 11 V and check the following test points: TP1, +8 V; if incorrect, check L3, D7, C27 and C28; TP5, less than +1.2 V. If incorrect, check D6, D5, R27, R26, D4, D3.

5. Increase the supply voltage to 20 V dc. Repeat Step 4. TP1 should still read +8 V; TP5 should show about +9 V. If not, check all components mentioned in Step 4. This checks out the remote tuning circuitry. If all's okay, proceed with the next step.

6. Connect a 75-Ω coax cable to the junction of C19 and L3 (center conductor) and ground (shield braid). Terminate the end of the cable in a connector suitable for your TV or monitor (generally an F connector). Tune the TV to channel 3 or 4 (whichever is unused in your area) and set the TV's controls for normal reception. If you have a sensitive RF millivoltmeter, use it instead of a TV as the output indicator as it's easier to interpret. Connect a signal source to the down-converter input and ground. Use 50-Ω low-loss cable and keep connections *short*. The signal source can be a generator or on-air

signal. Preset the trimmer capacitors as follows: C1, 40% mesh; C8 and C9, 20% mesh; C22, 75% mesh. Set R24 to its center position. Connect +12 to 14 V to D8, negative lead to ground. Keep the bottom of the PC board at least 1/2 inch above any metal, wood or plastic to avoid detuning. A set of four 1/2 or 3/4-inch standoffs installed in the board's four corner holes is ideal for this purpose. Use only a *nonmetallic* tuning tool for all adjustments. Plastic tools having small metallic inserts may work, but can be a source of slight error because the insert adds a small but significant amount of capacitance.

7. Activate the signal source and *slowly* rotate C22 until some indication of reception is seen on the monitor or RF voltmeter. Use a fairly strong signal at first. On confirmation of reception, decrease the signal to a level just sufficient to maintain a reliable indication. As you remove the tuning tool from C22, some detuning will occur. You'll have to compensate a little to get the tuning correct when the tool is removed. If you have a frequency counter, you can use it to simplify this step.

Tune-Up with a Frequency Counter

Do not connect any probes, cables, or wires directly to the oscillator circuit or any of its components: Use loop coupling. You may have to experiment with the coupling. Couple the counter to Q3, staying at least one-half inch away from C22 and Q3. With R24 centered, set C22 for 372 MHz ± 3 MHz. You must obtain a steady reading. The counter may be connected to the emitter of Q2 through a 220-Ω, 1/8 or 1/4-W resistor, but that may detune the oscillator by 5 or 10 MHz. Counters with low sensitivity above 400 MHz, however, may require this approach as the only way to get a steady, reliable reading. Once you're in the ballpark, you can compensate for the detuning by touching up C22.

When you have a steady reading and you're reasonably sure it's valid, check the LO tuning range. Rotate R24 through its

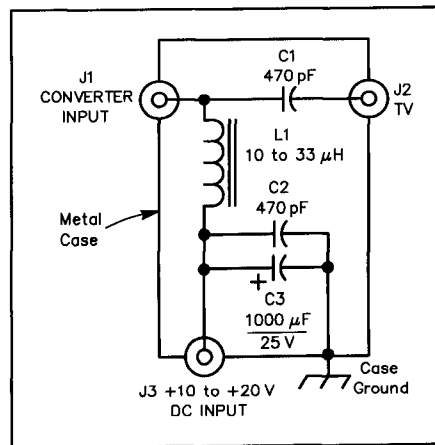


Figure 2—A dc block for remote tuning of the 440-MHz converter. J1 and J2 are F connectors; J3 is a chassis-mount female phono jack or other dc power connector. A die-cast aluminum box with a tight-fitting cover makes an ideal enclosure. See Note 1.

entire range. For the 420 to 440-MHz band, the LO should cover 358.75 to 378.75 MHz (using a channel 3 IF). Most ATV activity on 440 MHz is between 426 and 440 MHz. Keep the tuning range as narrow as possible to improve the tuning rate and ease of tuning. Adjust C22 as necessary to ensure desired coverage. Spread or squeeze together the turns of L7 and adjust C22 to alter the tuning range. For other IFs, the LO tuning range can be shifted lower (higher IF) or higher (lower IF). The LO must be *below* the signal frequency or the IF signal will be inverted with respect to the input signal.

Tune-Up without a Frequency Counter

If you don't have a frequency counter, you'll have to depend on the reception of a known signal, or use a calibrated receiver to pick up the LO signal. If you have no counter, receiver or analyzer, don't worry. Using a known signal, set C1, C8, C9 and C22 to the presets mentioned in Step 6. Set R24 to the center of its range. *Slowly* adjust C22 until you see some indication on the output indicator connected to the junction of C19 and L3. Confirm that this output is from the signal source by shutting off the source or disconnecting the input to the converter. For best results, keep the signal level as low as possible. If you have problems, make sure the signal hasn't gone off the air, that the trimmers are correctly preset and the output indicator is correctly set up and operating properly.

Once you have a received-signal indication, peak C1, C8 and C9 for maximum signal. Repeat this peaking until no further improvement is obtained. Recheck the setting of C22 to ensure the correct tuning range is obtained. Check your final settings against the presets. They shouldn't be too different if L4 through L8 are made and

installed correctly.

Your converter is now working! Little readjustment of the trimmer capacitors should be needed, although the adjustments are somewhat sharp. To ensure you have peak performance, you can repeat the adjustments. If you're a perfectionist (or just curious) and have access to a sweep setup, align the converter for a flat response within ± 2 dB across the amateur band. The alignment is simple and straightforward, so don't hesitate to experiment. If everything is okay, you should have a gain of about 40 dB and a NF of about 1.5 dB.

Mount the converter in a shielded box equipped with connectors of your choice. We recommend an N, TNC, SMA or BNC connector for the input. For the output, almost anything reasonable can be used, including an F connector. For mast mounting, be sure to weatherproof all connections. Check the converter's alignment after mounting it in any enclosure because some detuning may result. Such detuning is usually slight, but depending on the mechanical configuration, it may be significant.

For remote tuning, make sure your variable power supply's output is clean. Any noise or hum causes FM of the LO signal and a noisy received picture because the tuning voltage is unregulated. Be sure to set R24 fully CCW when you use remote

tuning, otherwise the converter's tuning range will be restricted.

This converter develops an overall gain of 37 to 43 dB. This may be too much when strong signals are present, resulting in overload of the TV/monitor. You can adjust the gain by altering the value of R11 (100 Ω) as follows: 43 dB, 200 Ω ; 34 dB, 47 Ω .

You can use a 200- Ω pot at R11 as a variable gain control. Because this portion of the circuit operates at the IF, use a pot and wiring techniques suitable for 70 MHz. Maintain the IF output below 100 mV RMS to prevent overloading the TV/monitor.

R11's value assumes a nominal gain of 40 dB. We don't recommend attempting to increase the gain beyond that. To reduce RF gain for very strong signals, apply a negative bias of 0 to -10 V to TP7 through a 220-k Ω resistor. You can obtain this bias by connecting a pot across a -10-V dc supply. The potentiometer functions as an RF gain control. Reverse AGC from the TV/monitor can be arranged to bias TP7 from +1.5 V at zero signal to -3.0 V on strong signals. (Because TV circuits vary, the means for accomplishing this are left to your ingenuity.) Typically, 35 to 40-dB RF gain reduction can be obtained using either of these approaches.

Another gain-reduction method uses a manually operated switch to ground

TP7. This reduces RF gain approximately 10 dB. This switch can be a simple SPST switch. For greater gain reduction, connect the switch to a -1 to -3 V source.

Our next installment will describe a companion 2-W, 3-channel ATV transmitter. Join us!

Notes

An etched and drilled PC board and parts for the converter (not the circuit of Figure 2) are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053. Contact them for details; tel 914-235-6611; fax 914-576-6051. Catalogs can be purchased for \$1 (refundable with the first order) and a #10 envelope bearing 75 cents First-Class postage.

A template package containing the double-sided PC-board pattern and a part overlay is available from the Technical Department Secretary, ARRL, 225 Main St, Newington, CT 06111. The price is \$2 postpaid for ARRL members (\$4 for nonmembers). Please identify your request for the 440-MHz ATV DOWNCONVERTER TEMPLATE.

Between the two of them, Rudolf Graf, KA2CWL, and William Sheets, K2MQJ, have 80 years of experience in virtually every aspect of electronics. They've had more than 30 books published during the past 35 years and their articles have appeared in every major electronics publication.

You can contact Rudolf Graf at 111 Van Etten Blvd, New Rochelle, NY 10804, and William Sheets at PO Box 200, Hartford, NY 12838.

QST

Strays

A HAPPY HAM COINCIDENCE

♦ Art Erdman, W8VWX, was searching past issues of *QST* for early technical articles on ground-plane antennas. After reading one in the May 1947 issue, Art, noticed an article on the following pages by a fellow worker of long ago, Neil Handel, W6WXW. Art looked in the 1996 *Callbook* and saw no listing of W6WXW—no surprise, since 49 years had passed. Then, continuing to browse in the pages of the old *QST*, he saw a photo of the ham station of L. W. Franklin, W2BF. Since the *Callbook* was still at hand, Art looked up W2BF, and found that it is currently issued to Neil Handel! A telephone call quickly confirmed that this was ex-W6WXW, and the two former coworkers enjoyed the chance to become reacquainted. By an extraordinary coincidence, Neil had requested that call sign when he upgraded to Extra. Now if only Art could just be that lucky with the state Lotto....

MORE HAM SCHOLARSHIPS AWARDED

♦ The Central Arizona DX Association recently awarded \$500 scholarships to John Steenis, K17LZ, Phoenix, Arizona, and Sarah Laurel Brown, N7XYR, Page, Arizona. Both have exemplary grades and are active hams. Additional information about the CADXA scholarship program may be obtained from

Gary Capek, K8BN, 5403 W Dobbins, Laveen, AZ 85339, 602-237-4314, gcapek@getnet.com.

TIS TNX W2OTS

♦ The ARRL Technical Department wishes to thank Mort Hans, W2OTS, for his recent donation of a rare book to the TIS Library at HQ. Mort donated his first-edition copy of Clinton B. DeSoto's *Calling CQ*, autographed by the author, W1CDB, and published in 1941. The book is a collection of adventures of Amateur Radio operators that depict many significant events in early ham radio history. Mort found the book at a recent tag sale and remembered it from his days as a teenager, when it helped fan his interest in our hobby.

W6YO PLAYS THE SPOONS

♦ Most people have heard of playing the spoons as a rhythm instrument, but Jules Wenglare, W6YO, found a new way to play a tune on them. Jules was on a Russian icebreaker, under way on a 48-day, 10,000-mile voyage from Ushuaia, Argentina, to London. Jules hadn't intended to use CW on the trip, so he didn't have a key on board. Then he heard two long-time friends on 20-meter CW—Don, W6BVM, and John, W6UZ/4. Jules borrowed two spoons from the steward, taped a wire to each spoon, taped the spoons throughout their length, except for the ends of the handles, then taped the whole thing to the operating table. Crude as it was, it worked, and he surprised his long-time Voice of America friends the following day, spooning out interesting tidbits to them about his voyage. Later on, he ran across Bob, W3KW, whom Jules has worked when Bob was aboard a Russian

nuclear-powered icebreaker several years earlier. Jules will probably *not* leave his key at home in the future!

I would like to get in touch with...

♦ Hams who are present or past students or staff members of the New York State School for the Blind, to determine the interest in operating a Field Day station at a future alumni reunion. Diane Askew Scalzi, W18K, 21621 Briarcliff, St Clair Shores, MI 48082.

♦ Hearing-impaired hams who would share their experiences with a group of deaf and hearing-impaired children I'm working with in the central Florida program called New Friends. John Rothert, KC4IYO, 14131 Hunter Grove Dr, Orlando, FL 32828-6115; 407-380-5716.

♦ Anyone who knows what happened to James H. Dooley, MD, W2JCT. Jim was a medical officer with the First Battalion, Seventh Marines, First Marine Division, who was stationed in Hopeh Province, China, in 1946, where he operated as XU1YR. Marvin Fein, W2AH, 21 Harbor Ridge Dr, Newport Beach, CA 92660-6815.

♦ Anyone who has converted a Heathkit SB-610 monitor scope to display received signals from a Kenwood TS-850S. Gale Eckenbarger, W1HBZ, 18 Lehigh Ave, Clifton, NJ 07012, 201-773-2570.

♦ Anyone who has Texas Electronics weather instruments and indicators that were used by cable TV systems in the 1960s and '70s. I'm interested in complete systems (working or not) or parts. Bill Robinson, KB5ASR, 198 Skyland Dr, Meridian, MS 39301, 601-693-1441.

By William Sheets, K2MQJ, and Rudolph F. Graf, KA2CWL

Get on 440-MHz ATV!

Last month, we described a 440-MHz converter² to get you started on ATV. Sooner or later, you're sure to tire of simply viewing—you'll want to transmit. You can do that with this 440-MHz, 2-W transmitter. It's based on a well-proven design and is similar to the 915-MHz ATV transmitter published earlier in *QST*.^{3,4} It requires a nominal 13.8-V dc supply and generates an NTSC video signal and 4.5-MHz FM sound subcarrier. You can use the transmitter for normal ATV station use, as a video link for a radio-controlled model airplane, balloons and for portable ATV work. With a small PC-board camera,⁵ a 10-element Yagi and the converter described last month, you'll give a good account of yourself in portable work—especially from a high hilltop location and when working through ATV repeaters.⁶

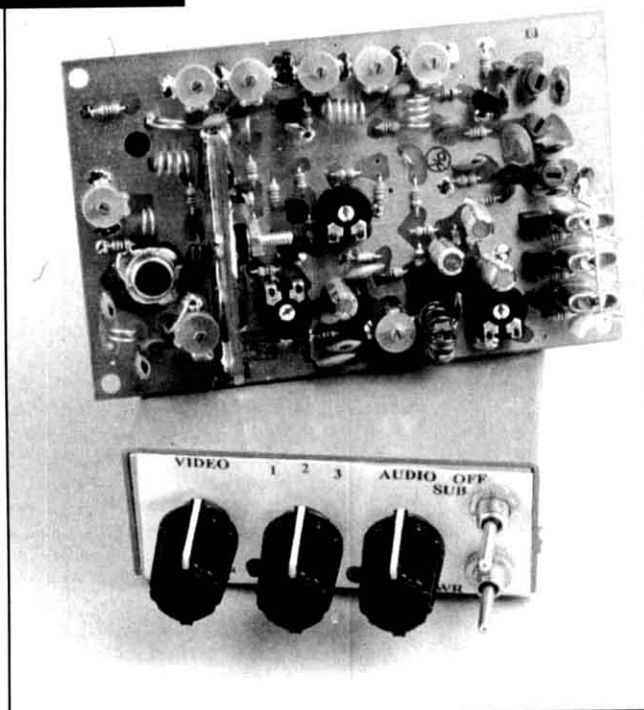
Although 440 MHz is congested in the larger metropolitan areas, there's plenty of US territory where the band isn't as crowded. With the transmitter's three-channel capability, you'll have some degree of frequency agility.

General Description

Figure 3 is a block diagram of the transmitter. Transmitter power output is typically 1.5 to 3 W PEP with a 10 to 14.4-V dc power supply. PIN-diode crystal switching permits easy frequency changing; broadband multipliers eliminate the need for retuning when switching frequencies. RF output is constant within about 0.5 dB from 420 to 440 MHz. You can turn off the 4.5-MHz sound subcarrier by means of an optional switch. That's useful where a talk channel on another frequency is used (commonly 2-meter FM). The audio can also be set up for the PAL system 5.5-MHz sound subcarrier.

A standard NTSC or PAL video-input signal (1 V P-P at 75 Ω , negative sync) feeds

Part 2: A 2-W, 3-Channel ATV Transmitter



the transmitter. The video amplifier and modulator are dc coupled. A capacitor can be installed in series with the input if ac coupling is desired. No sync stretcher is needed, as the modulator is quite linear. Video quality is excellent. Audio inputs from 5 mV up to 1 V can be accommodated, and most microphones can directly drive this transmitter without a preamplifier.

Depending on your construction experience, you can assemble this project in two to five sessions. There are some small parts to handle, so have suitable tools on hand. If you're an average ham with some RF experience, you'll have few—if any—problems.

Components and a PC board are available (see Note 4).

Circuit Operation

Refer to Figure 4. Q1 uses one of three crystals in the 52 to 55-MHz range selected by PIN diodes in a dc-controlled switch. R1, R2 and R3 bias Q1's base. One resistor at a time receives voltage from **FREQUENCY SELECTOR** switch S1. The selected PIN diode conducts, inserting its associated crystal in series between the base of Q1 and ground. The two unbiased diodes appear as open circuits and their associated crystals are effectively out of the circuit.

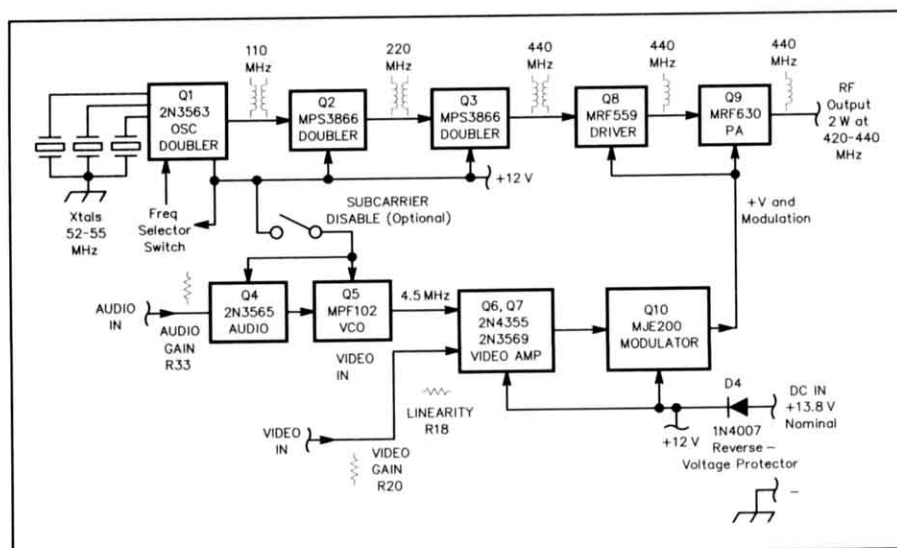


Figure 3—A block diagram of the 440-MHz ATV transmitter.

¹Notes appear on page 42.

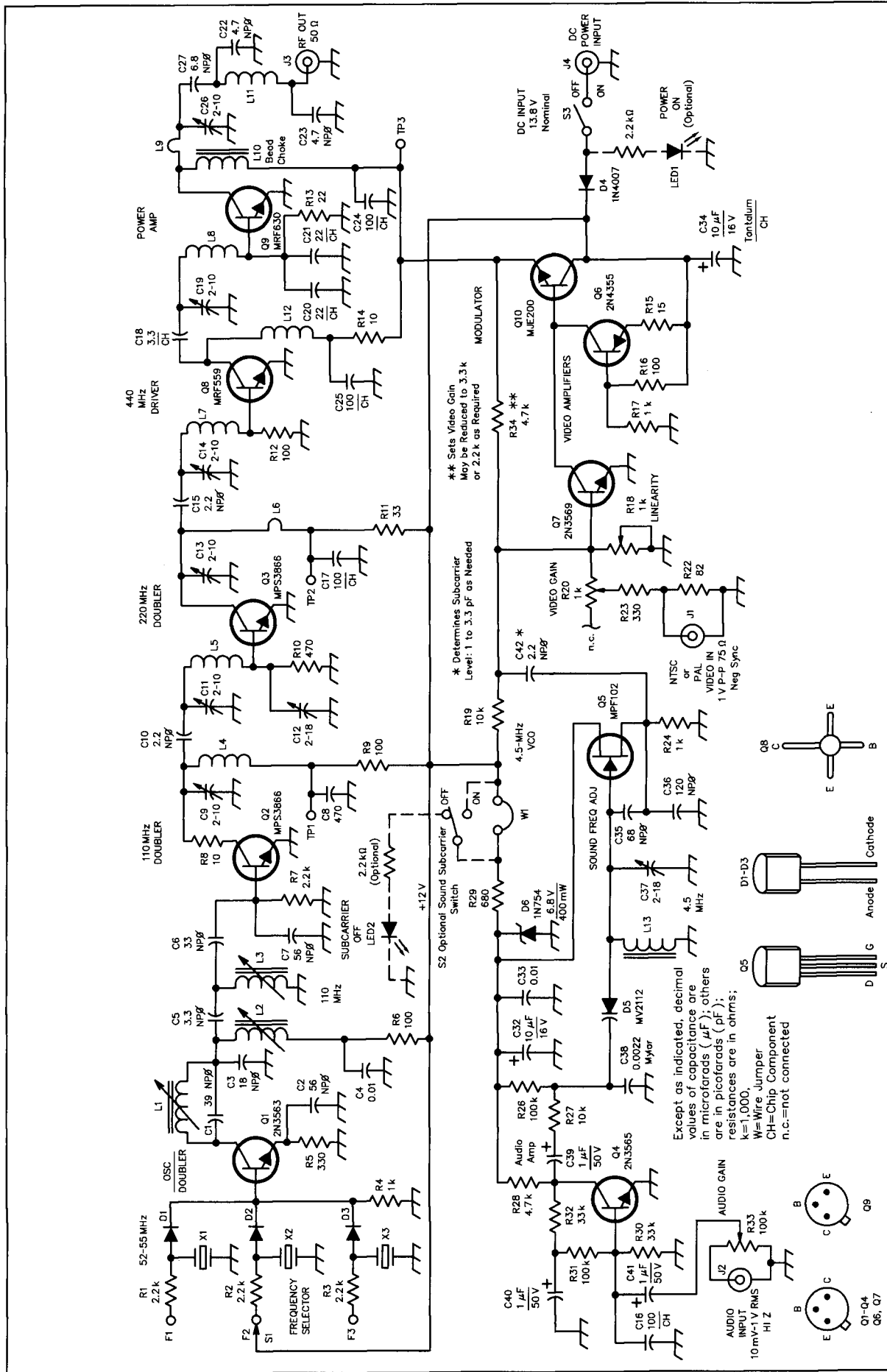


Figure 4—Schematic of the 2-W, 440-MHz ATV transmitter. Resistors are 1/8-W 5%-tolerance units unless otherwise specified. Equivalent parts may be substituted.

We depart from QST style in identifying some components in order to agree with the authors' existing materials.

C9, C11, C13, C14, C19, C26—2 to 10-pF trimmer
C12, C37—2 to 18-pF trimmer
C16, C17, C24, C25—100-pF chip 1206
C18—3.3 pF chip 1206
C20, C21—22 pF chip 1206
C28, C29, C30, C31 (reserved, not used in this circuit)
C32—10 μ F, 16 V electrolytic
C34—10 μ F, 16 V chip tantalum
C35—68 pF NP0 or silver mica
C36—120 pF NP0 or silver mica
C38—0.0022 μ F, 50 V Mylar
C39, C40, C41—1 μ F, 50 V electrolytic
D1—D3, incl—MPN3404 PIN diode
D4—1N4007 1 kV, 1 A
D5—MV2112 voltage variable capacitance diode
D6—1N754 6.8-V, 400-mW Zener diode
LED1, LED2—Optional LED with 2.2-k Ω , 1/8-W resistor in series
J1, J2—Phono jack
J3—Chassis-mount female BNC connector
J4—Dc power connector of choice
L1—L12—See Table 3
Q1—2N3563
Q2, Q3—MPS3866
Q4—2N3565
Q5—MPF102
Q6—2N4355
Q7—2N3569
Q8—MRF559 or MRF627
Q9—MRF630
Q10—MJE200
R18, R20—1-k Ω PC-board or panel-mount pot
R21 and R25—(Reserved—not used in this circuit)
R33—100-k Ω PC-board-mount pot
S1—1-pole, 3-position rotary or slide switch
S2—SPDT miniature toggle switch
S3—SPST miniature toggle switch
X1—54.90625 MHz crystal, HC-49/U holder
X2—54.25000 MHz crystal, HC-49/U holder
X3—53.28125 MHz crystal, HC-49/U holder
Misc: #22 and #32 enameled wire; #22 bare tinned wire; TO-220 mica insulator; TO-220 heat sink; hardware; enclosure (1 1/4 × 2 3/4 × 5 1/2 inches HWD).

Q1 operates in a common-base oscillator circuit. At the series-resonant frequency of the crystal, Q1's base is virtually grounded. L1 and C1, tuned slightly above resonance, cause oscillation at the crystal frequency. The signal generated contains harmonics. Filter L2, C3, C5, L3, C6 and C7 couples the second harmonic (105 to 110 MHz) to Q2, which doubles its input frequency to output 210 to 220 MHz. Filter C9, L4, C10, L5, C11 and C12 eliminates unwanted frequencies and provides impedance matching to Q3. Q3 doubles its input signal to the output frequency in the 420 to 440-MHz range. About 50 mW of RF energy is present at Q3's output. C13, L6, C15, C14 and L7 comprise a matching network to couple this energy to driver stage Q8 and remove spurious signals. Q8 amplifies its input signal to between 0.2 and 0.4 W, depending on supply voltage. C19, L8, C20, and C21 match Q8's collector impedance to the base of power amplifier Q9. L12 is an RF choke.

R13 provides bias for Q9. Q9 delivers 2 W or more to its load via the following matching network. L10, L9, C26, C27, C22, L11 and C23 form a tuning and matching network and low-pass filter to ensure a spectrally clean RF output to the antenna. Q9 handles considerable power, so its case is soldered directly to the PC board's groundplane to help dissipate heat and to assure a low-inductance emitter return.

Modulation

To modulate the video carrier, the supply voltage for Q8 and Q9 is taken from the emitter of modulator Q10. Q6, Q7, and Q10 are connected as a feedback amplifier with a nominal gain of 5 to 10. (The gain is determined by R34's value and the setting of R20.) Video-signal input to the transmitter at J1 is amplified in this feedback amplifier circuit and inverted so that sync and black levels are positive-going. The video signal at the emitter of Q10 is superimposed on the dc supply voltage to Q8 and Q9, causing amplitude modulation of Q9's RF output. R18 adjusts the RF output carrier level for symmetrical modulation. R20 is set for maximum modulation level without distortion or clipping.

D4 protects the circuit from an incorrectly connected power supply; C34 provides supply line bypassing. For lowest impedance, use a tantalum chip capacitor at C34. Q10 is effectively in series with the power supply to the RF power amplifier and dissipates considerable power, therefore, it's heat-sinked. The video amplifier is dc coupled, so pay attention to video-input dc levels and other interfacing considerations.

To carry audio, a 4.5-MHz FM subcarrier must be generated. Incoming audio is fed to **AUDIO GAIN** control R33. C41 feeds the audio to Q4, which has a gain of about 150. Audio from Q4 drives varactor diode D5 via R27 and C39. D5, along with C37, C35, C36 and L13, makes up the 4.5-MHz frequency determining network of the subcarrier oscillator, Q5. Audio voltage applied to D5 changes its capacitance, re-

sulting in FM of the subcarrier.

C37 sets the 4.5-MHz sound subcarrier frequency. Subcarrier from Q5 is fed via C42 to the video modulator where it is mixed with the video. C42's value (1 to 3.3 pF) sets the subcarrier level. If sound isn't required, Q4 and Q5 can be disabled by removing the jumper (W1) that's in series with the power-supply line to D6 and R29. (For flexibility, a switch can replace W1.) D6, C32 and C33 supply a clean, regulated 9-V bias to Q4 and Q5.

The dc power supply should be clean and stable, delivering less than 50 mV of ripple and noise. (This shouldn't present any problems; most decent quality supplies easily meet these specifications.) Any noise or ripple on the supply voltage can modulate the RF carrier and/or shift the carrier level, causing sync clipping or interference in the received video.

Construction Hints

Pay attention to a few basic precautions when assembling this transmitter. Solder all ground leads of trimmer capacitors and resistors on *both* sides of the board. This is essential for good RF grounding. The case of Q9 must be soldered to the top of the board. Certain parts—such as the chip capacitors and Q8—are mounted on the bottom of the board. Mount all parts close to board; *no* exceptions. "Zero lead length" is a must in 440-MHz RF circuits.

The transmitter typically outputs 2 to 3 W peak on sync tips. This means that about 5 W of heat is generated. Mount Q10, metallic side down, to the heat sink. Install a mica insulator between Q10 and the heat sink. Position Q10 to face the right side of the PC board. It may be necessary to trim excess from the mica insulator. Don't use silicon grease as it isn't needed. Don't overtighten the #4-40 hardware, and make sure no leads of Q10 show electrical continuity to the heat sink. Install the heat sink and Q10 vertically on the PC board. Because this transmitter is physically small, special attention is given to thermal considerations. The G-10 shield can be replaced with a metal (copper or brass) plate fastened to a chassis or a radiator fin. See Figure 5. Solder as much of the seam on both sides of the heat sink as possible. Use a hot, fine-tipped iron.

Next, fabricate all coils. Make L8 and L9 slightly longer than specified to allow room for final tweaking. L13 has an extra turn that may need to be removed; this is determined during the final test procedure. Be sure there are no shorted turns on L4, L5, L7, L8, L11 and L12. L1 has its bottom turn connected to the junction of C1 and the collector of Q1, L2's bottom turn connects to the junction of C3/C5, and L3's bottom turn to the junction of C5 and C6. Use a #8-32 screw to hold L1, L2 and L3 during installation. After installing the coils, remove the screw and insert the ferrite slugs fully into the coils.

Next, install chip capacitors C16, C17, C18, C24, C25 and C34 on the *bottom* of the PC board. Chip caps C20 and C21 will be installed later.

Q8's long lead is its collector. Install Q8 so that its leads are flush with the bottom of the PC board. Install Q9 so that its case is tight against the groundplane foil.

The case of Q9 is connected to its emitter, not its collector. Solder the case of Q9 to the groundplane to assure good grounding and heat sinking. Install C20 and C21 between the base of Q9 and ground.

Carefully inspect your work. Look for solder shorts, poor joints, missing parts, incorrect part placement and incorrect compo-

nent orientation. Once everything is satisfactory, you're ready to check out the transmitter.

Tune-up

To successfully test and tune up this transmitter you should have an understanding of the circuit operation, and have access to some basic test equipment including a:

- VOM or DVM—use an analog VOM because they are easy to read and interpret while performing peaking adjustments. It's easier to interpret a moving needle than a wildly changing digital readout.

- 50- Ω dummy load usable at 500 MHz. (Most ham, CB and hobby dummy loads sold for HF and 2-meter use *aren't* reliable 50- Ω loads at 440 MHz.) Use a Bird, Motorola or other professional wattmeter suitable for UHF two-way radio servicing. A relative reading is okay as long as the termination is a good 50 Ω at 440 MHz.

- A 15-V variable-output dc power supply. Its regulation should be 1% or better from no load to full load.

- Source of video (1 V P-P into 75 Ω , negative sync) and an audio-signal source. A camera, camcorder or VCR will do.

- TV receiver capable of tuning 420 to 440 MHz. Usually, a TV receiver tuned to channel 3 or channel 4, and fed with a tunable ATV converter will do. Newer cable-ready TV receivers cover frequencies in this range.

- Frequency counter or other means of measuring 4.5 MHz and—if possible—up

to 500 MHz.

Don't try to tune this transmitter solely for "best picture." You'll get nowhere—fast! First we'll check and tune the RF circuits for best performance and maximum output into a 50- Ω load. Then, we'll make certain modulator adjustments. Only after that's done is video connected to the transmitter. At this point, only small adjustments are necessary. Video quality should be excellent, so don't settle for less.

Refer to Figures 3 and 6. Attach a 50- Ω dummy load to J3. With power off, make the following ohmmeter checks:

Junction of C29/L11 to ground: infinity
Q8 base to ground: 100 Ω
Q9 base to ground: 22 Ω
Q8 collector to TP3: 10 Ω
Q9 collector to TP3: <0.1 Ω
Junction of L9/C26 to TP3: <0.1 Ω
Junction of C18/C19/L8 to ground: 22 Ω

Next, connect a dc supply to the transmitter with the negative lead to ground foil, positive lead to the anode of D4. Set the power supply to 0 V. If your supply has no ammeter, insert an ammeter in series with the positive lead to D4. Now *slowly* raise the power-supply voltage to 13.8 V, watching the ammeter. Only a small current should flow (less than 100 mA). If over 150 mA is drawn before reaching 13.8 V, there may be a short or other problem. Watch for any smoking components. If all's okay, check for the following voltages with the negative lead of VOM connected to ground and the power supply set for 13.8 V:

Q1 collector	>+12.5 V
Q2 collector	>+12.5 V
Q3 collector	>+12.5 V
Junction of R29 and D6	+6.8 \pm 10% (is W1 installed?)
Q4 collector	+3 to 4 V
Junction of D5 and C38	+6 to 6.8 V

If these checks are satisfactory, center the **VIDEO GAIN** (R20) and **LINEARITY** (R18) controls. Connect your VOM's positive lead to Q10's emitter (TP3). Rotate R18 end to end. The voltage at Q10's emitter should vary smoothly between at least 2 to 12 V. If it doesn't, adjust R20 a little in either direction. (R20 varies Q10's emitter voltage slightly.) Leave R18 set for about 6 or 7 V at Q10's emitter. Preset C37 to half mesh. Connect a frequency counter to the emitter of Q10. You should obtain a stable reading somewhere around 4.5 MHz. If needed, adjust R18. Set C37 for a reading between 4.495 and 4.505 MHz. If you're unable to reach this frequency, add turns to L13 if the frequency is too high, remove turns if it's too low. An oscilloscope will confirm the presence of the subcarrier at emitter of Q10. If you don't have a frequency counter, you can use a shortwave receiver (with its antenna lead near Q10) tuned to 4.5 MHz to listen for the 4.5-MHz carrier.

When done, shut off the power supply. If all is okay so far, you can assume that the audio, video and modulator sections are functioning and that there are no major problems.

Rig up a test lead so that you can enable

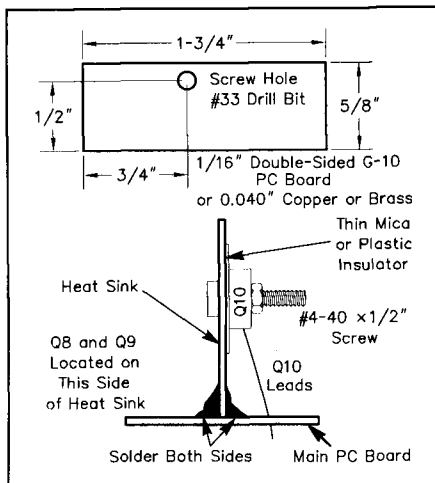


Figure 5—Heat-sink dimensions and Q10 mounting. Q10's collector (middle) lead should show no continuity to the heat sink.

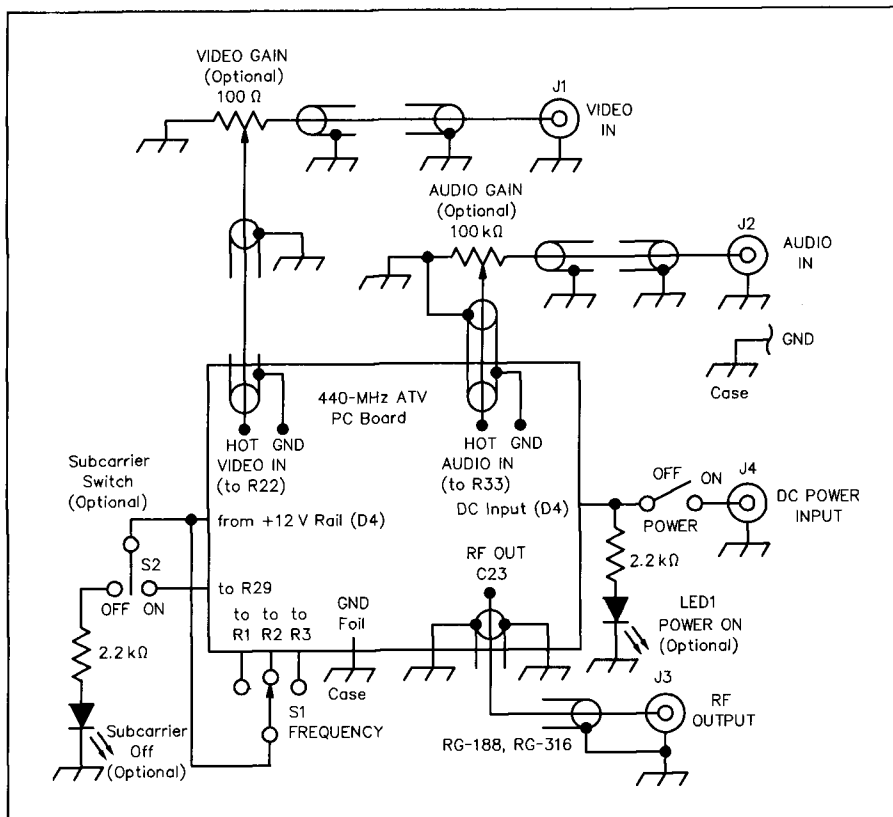


Figure 6—PC board interfacing and wiring.

each crystal in the oscillator circuit by applying 13.8 V to R1, R2 and R3, one at a time. This selects X1, X2, or X3 respectively. Next, make the following presets:

L1, L2, L3—Slugs inserted so 0.1 inch (3 threads) projects from the top of the coil

C9	30% meshed
C11	75% meshed
C12	40% meshed
C13	20% meshed
C14	15% meshed
C19	20% meshed
C26	20% meshed

Connect the positive lead of your VOM to TP1. Apply 13.8 V to the transmitter. Enable X2 and slowly back out the slug in L1. Use a nonmetallic tool only. Watch for a sudden drop in the voltage at TP1. The reading will start out at full supply voltage and drop 0.5 V or more. Back out the slugs in L2 and L3 to maximize this drop. It is possible to obtain a drop of 2.5 V or more. Enable X1, then X3, and repeat the procedure. Switch back and forth between the crystals until you get as much a voltage drop as possible with each crystal activated without having to make readjustments. Some compromise may be necessary.

Connect your VOM to TP2. Enable X2 and adjust C9 and C11 for lowest voltage at TP2. Enable X1 and X3 in turn and repeat the adjustments for obtaining the lowest voltage at TP2. Readjust L2 and L3 to get the voltage at TP2 as low as possible with all three crystals in turn. Again, some compromise may be needed. The object of this exercise is to get Q3 to draw 30 to 60 mA with each crystal activated. This ensures adequate RF drive to the PA at all three frequencies.

C12 may be adjusted if needed, but if this provides no improvement, return C12 to its preset position. The final settings of the trimmer capacitors should not be radically different from the presets if your coils have been made correctly and the chip capacitors are properly installed. If you have difficulty in obtaining the stated results, any radical variations in the trimmer settings may indicate problems or incorrect tuning. Regard this as suspicious should other problems be encountered. The tuning networks have a wide range and if the coils are made incorrectly, it's possible for the Q2 and Q3 stages to triple instead of double their respective input frequency. Locate and correct any problems before proceeding.

Final Tune-Up and Checks

Now, we'll tune up the PA and make the video checks. Make sure the RF from the transmitter doesn't interfere with your video source. A number of otherwise fine video devices are very poor at rejecting strong RF fields. They may be made inoperative or even damaged by RF. Don't be fooled into tracing nonexistent "transmitter problems."

Connect the transmitter RF output cable to a dummy load and an RF-output indicator known to be good at 440 MHz. A relative indicator is okay, but you will not be able to measure actual power output. Set R18 fully clockwise. Check the resistance to ground at the emitter of Q10. If it measures 10 Ω or less, a short exists in the power amplifier stages (Q8 and Q9). Find the short and eliminate it before applying power. A resistance reading of a few hundred ohms or more is okay. Reverse the meter leads and take the higher reading as the correct one. Tempo-

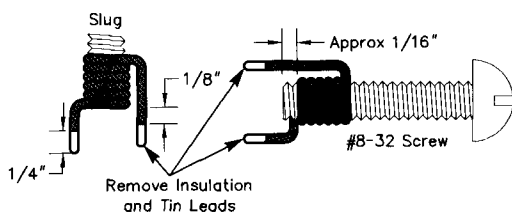
rally disconnect the lead to S1's arm. Apply +13.8 V to the transmitter at the D4 power connection. Measure the voltage at the emitter of Q10 and verify that adjusting R18 can decrease this voltage to less than 3 V. Reset R18 for full voltage. Reconnect the lead to S1's arm and enable X2. While observing the RF-output indicator, adjust C13 and C14 for maximum RF output, then do the same with C19 and C26. Repeat the capacitor adjustments to ensure maximum output.

Next, try crystals X1 and X3. On all three frequencies, the RF output should be within a 10% range. Readjust as needed. When properly tuned up, you should obtain about 2 W or more on the three crystal frequencies without adjustment. The transmitter should function with a dc supply voltage of 10 V. It should come on below 10 V on all three channels. If needed, adjust L1, L2, and L3 to achieve this, and possibly C9, C11, C12, C13 and C14 as well. Expect to spend a little time optimizing everything and don't be afraid to experiment. You can always realign from scratch if you mess things up. Actually, none of the adjustments is critical and once you get the feel of it, the alignment is quickly done. Run the transmitter into the load for about two to three minutes. The heat sink will get quite warm, but not too hot to touch for a few seconds. This is normal. If this bothers you, or if continuous-duty or cooler operation is desired, use a larger heat sink.

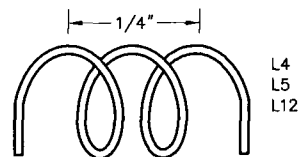
Audio and Video Alignment

Now, we'll set up the transmitter for video and audio. Remove dc power and connect a video source to J1. Make sure your video source delivers 1-V P-P negative sync, 75- Ω , NTSC or PAL video. This is pretty much

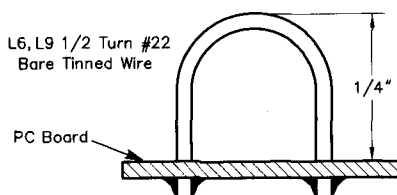
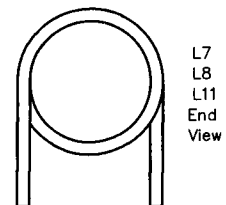
Table 3
Coil Data



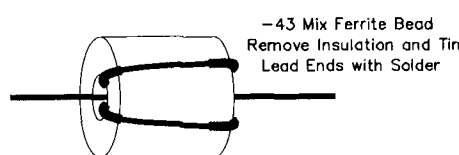
- L1 7-1/2 Turns Wind each coil on a #8-32 screw.
 L2 3-1/2 Turns Form leads as shown.
 L3 3-1/2 Turns Remove enamel and tin lead ends.
 #22 Enameled Wire Install on PC board using screw as a holder.
 Remove screw from coil by rotating screw ccw.
 Thread in a #8-32 Cambion slug.



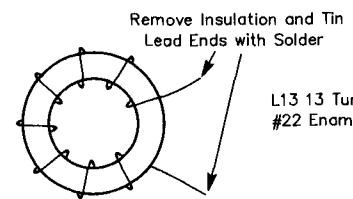
- L4, L12 4 Turns Wind each coil on a #8-32 screw.
 L5 5 Turns Form leads as shown.
 L7, L8, L11 1-1/2 Turns Spread turns evenly to fit PC board.
 #22 Bare Tinned Wire



Wind each loop on a #8-32 screw.
 Form Leads as shown.



L10 3 Turns #32
 Enameled Wire



Wind coil on an Ferroxcube 266T125-4C4 core.
 Each pass through the hole counts as 1 turn.
 Remove enamel and tin lead ends.
 Install on PC Board close to surface.

standard for most video sources. Check with a scope if in doubt. Connect an audio source to J2; line-level audio is okay. (A VCR is a good source of video and audio signals.) Input levels should initially be zero. Set R18 and R20 at mid position and R33 at 1/4 open (9 o'clock). Turn on a TV receiver and tune it to 439.25 MHz. Enable X1 and turn on the video and audio sources. Apply 13.8 V dc to the transmitter. You should get a picture on the TV set. Adjust R18 for a stable picture, then R20 for best contrast. Readjust R18 and R20 for best video and maximum output power without black or white clipping of the received video. If results seem poor, make sure you're not overloading the TV receiver or experiencing RF feedback to your video source. Adjust R33 for best audio. Recheck C37 and reset it, if needed, to correct for audio distortion. Repeat these tests using the other crystals to confirm proper operation.

This completes the testing. The transmitter draws about 550 to 700 mA at 13.8 V,

depending on the modulating signal. Don't exceed a dc supply of 15 V or expect optimum results with less than 11 V. Remember that power-supply noise can modulate the video and a low supply voltage can cause sync clipping. If a low supply voltage is expected, use that level when setting R18 to avoid problems.

Summary

Mount the transmitter in a case and add jacks, controls, labels, etc. Be sure to provide access to adjustments that may be needed at a later date.

In our next installment, we'll show you how to interconnect the converter and transmitter and complete your 440-MHz ATV station.

Notes

²Rudolf Graf, KA2CWL, and William Sheets, K2MQJ, "Get on 440-MHz ATV!—Part 1: A 440-MHz Downconverter," *QST*, Oct 1996, pp 36-40.

³Rudolf Graf, KA2CWL, and William Sheets, K2MQJ, "An ATV Station for 915-MHz," *QST*, Nov 1994, pp 23-29, and Dec 1994, pp 28-32.

⁴An etched and drilled PC board and parts for this project are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053. Contact them for details; tel 914-235-6611; fax 914-576-6051. Catalogs can be purchased for \$1 (refundable with the first order) and a #10 envelope bearing 75 cents in stamps for First-Class postage.

A template package containing the *double-sided* PC-board pattern and a part overlay is available from the Technical Department Secretary, ARRL, 225 Main St, Newington, CT 06111. The price is \$2 postpaid for ARRL members (\$4 for nonmembers). Please identify your request for the GRAF AND SHEETS 440-MHz ATV TRANSMITTER TEMPLATE.

⁵PC-board cameras are available from a number of sources including North Country Radio (see note 4).

⁶You can find a listing of ATV repeaters in *The ARRL Repeater Directory*. To order your copy, see the *ARRL Publications Catalog* elsewhere in this issue.

QST

New Books

VIEWING THE EARTH FROM SPACE

By James Buchanan, K8WPI

Published by Woodhouse Communication, PO Box 73, Plainwell, MI 49080-0073; tel 616-226-8873. First edition, second printing, 1996, softcover, 8 1/2 x 11 inches, 137 pages, B & W illus. \$24, \$3 shipping and handling.

Reviewed by Steve Ford, WB8IMY
Managing Editor

Satellite images of our home planet are rather common these days. You probably see them every evening during the weather segment of your local TV newscast. If you're blessed with cable access that includes *The Weather Channel*, they're standard fare.

So why bother trying to receive these images on your own? One answer is that you get to view the images you want to see, not necessarily the ones the forecasters have chosen. But the answer for most image-viewing enthusiasts is similar to the one Sir Edmund Hillary allegedly gave when asked why he climbed Mt Everest. Quoting George Leigh Mallory, he replied, "Because it's there." Just as hams choose to communicate internationally with their own radios rather than use readily available telephones, imaging aficionados prefer to bypass meteorologists and cable networks in favor of grabbing their own pictures from space.

In *Viewing the Earth from Space*, James Buchanan takes a brass-tacks approach to the task of setting up receiving stations for various modes. He begins with HF WEFAX, probably the easiest mode for most of us. WEFAX stations throughout the world transmit detailed weather maps and satellite images primarily intended for ships at sea.

Getting started in WEFAX is relatively

easy. As Buchanan points out, all you need is a general-coverage receiver, an antenna, a demodulator (many of the multimode TNCs on the market will decode HF WEFAX) and PC or Mac-based software to display the results. The book apportions a number of pages to a discussion of antennas, feed lines and tuners, and rightfully so. Since you're dealing with short-wave reception—and all the noise, interference and fading that go with it—a good antenna system is your best assurance of success.

Part of what makes *Viewing the Earth from Space* an enjoyable read is the humor and opinion Buchanan uses throughout. For example, he describes the cold shoulder he received when trying to get information from the US Navy concerning its WEFAX stations. He is also critical of the poor transmission standards of stations such as the popular NAM based in Norfolk, Virginia. (The result is fuzzy, indistinct weather maps and satellite images.)

From HF, Buchanan jumps all the way to VHF and the APT (Automatic Picture Transmission) satellites. These Russian and American birds orbit at low altitudes, sending low-resolution images at about 137 MHz. You can listen to these satellites if your 2-meter FM rig has AM aeronautical receive coverage. When the satellites are overhead, you'll hear a rapid tick-tock sound. Unfortunately, you can't use your transceiver to pull down the image data (the receive passband isn't nearly wide enough). Even so, *Viewing the Earth from Space* gives you plenty of information and resources to assemble your own APT receiving station at home. As the book illustrates, APT reception is easier than you think.

Receiving images from the geostationary GOES satellites is the next step in complexity. As Buchanan states, the GOES birds are more than 22,000 miles away and use microwave downlinks. This means that loop Yagis or parabolic dish antennas are definite re-

quirements. So are low-loss feed lines, preamps and downconverters. The book gives you a complete "shopping list" and warns of potential pitfalls. Assembling a GOES station isn't easy, but you'll be rewarded with fascinating images, 24 hours a day.

The final and ultimate step in satellite image reception involves HRPT: High Resolution Picture Transmission. Buchanan spends only a few pages discussing this mode because, frankly, very few of us can afford the necessary hardware. HRPT images are stunning, and *Viewing the Earth from Space* provides several examples, but most of us are not ready to shell out \$4000 for the privilege of grabbing them ourselves.

Two chapters of the book are devoted to an aspect of this hobby that I didn't know existed: *mobile* image reception. The idea is to equip your car or 4x4 with all the gear necessary to receive satellite and WEFAX images during your travels. Buchanan does this quite a bit and is obviously keen on the idea (he uses about 50 pages to cover the topic). The only thing that isn't made clear is why you'd want to do it. But then we're back to Sir Edmund Hillary....

One of the things I liked most about this book is that it addresses the financial aspects of setting up an image-receiving station. Many books and articles breeze right past this point as if they're trying to avoid it. Instead, Buchanan is upfront with the reader. At the end of each section he gives a complete cost breakdown of the station described. You know exactly what you're getting into before you write the first check.

If you want detailed information on image transmission formats and the associated technology, *Viewing the Earth from Space* is not for you. If you want a down-to-earth (no pun intended!) game plan to set up your own satellite-image receiving station, you'll find it here—along with about 100 sample images to whet your appetite!

QST

By William Sheets, K2MQJ, and Rudolf F. Graf, KA2CWL

Get on 440-MHz ATV!

Part 3: Station Setup

The 440-MHz converter and ATV transmitter projects described in *QST's* October and November 1996 issues^{7,8} can be combined to produce a low-power ATV station with the addition of a few extra components: an antenna relay, a monitoring circuit and a power supply that delivers 1 A or more at 12 to 14 V dc. Because a single 12 to 14-V supply is all that's required, mobile and portable operation from a hilltop or other favorable site is simplified.

TR Switching

As shown in Figure 7, the TR switch can toggle the 12-V supply between the transmitter and downconverter and control one or more TR relays to switch the RF leads to the transmitter output and converter input. We used an inexpensive DIP relay mounted "dead-bug" fashion on a small piece of unetched PC board. (A coaxial relay would be a better choice, but is considerably more expensive.) With short leads, the insertion loss is about 0.5 dB. Use BNC, N or TNC connectors for all UHF cables and jacks; F connectors can be used at the converter IF output.

Monitoring

Monitoring transmitted waveforms with an oscilloscope is ideal, but you can (and should) monitor the transmitted picture. The line sampler shown in Figure 8 drives a monitor with a sample of the transmitted video signal. You can use a 12-V portable B&W or color TV set as a monitor by tuning it to channel 3 or 4, and feeding it with the output of an RF modulator via a commonly available TV-signal splitter. Video modulators can be salvaged from a junked VCR or video game or purchased new inexpensively.⁹

The capacitive voltage divider (C1 and C_s) in Figure 8 samples the RF voltage on the transmission line. C_s is made variable to control the signal pick-up level for different magnitudes of power output. An envelope detector consisting of a bias network and a hot-carrier diode (D1) recovers the modulation envelope. Emitter follower Q1 provides a low-impedance output to a scope or monitor. There's nothing critical about this circuit; it can be built dead-bug fashion. Use a metal enclosure for best RF shielding and

keep the connections between the RF jacks as short as possible.

Another monitoring technique allows part of the receiving converter to run in a desensitized state (LO and mixer running, RF stage cut off) during transmissions. The input to the converter in this configuration

must be carefully controlled to prevent converter overload and give a false indication of transmission quality. For this approach, the converter must be well shielded for proper control of RF input. Q1 of Figure 1 (Part 1) can be biased to cut-off by applying -3 V dc at its gate-2 terminal. Transmitted-signal

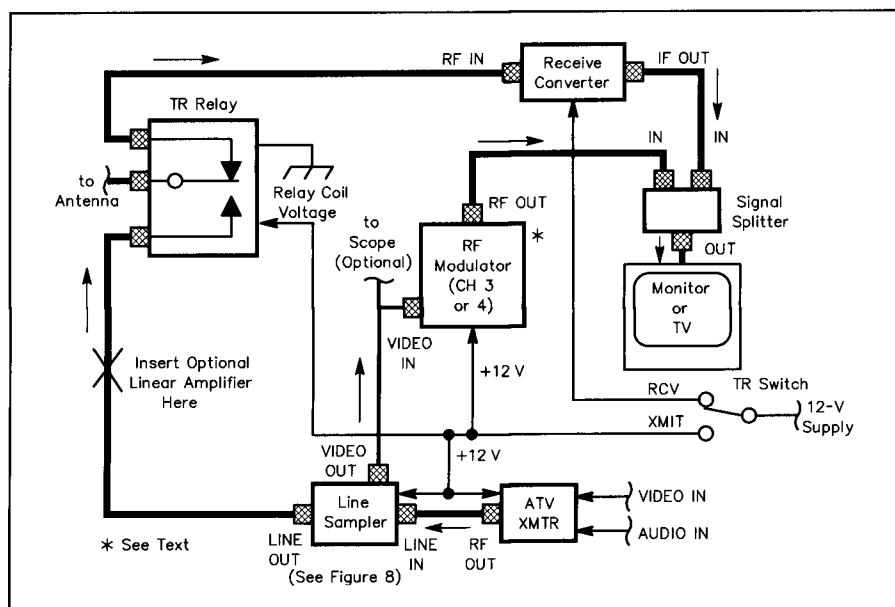


Figure 7—Station equipment interconnection and TR switching arrangement. A commonly available TV-signal splitter (Radio Shack 15-1293 or 15-1522, or equivalent device) feeds the monitor/TV with output from the receive converter and the sampled on-air signal.

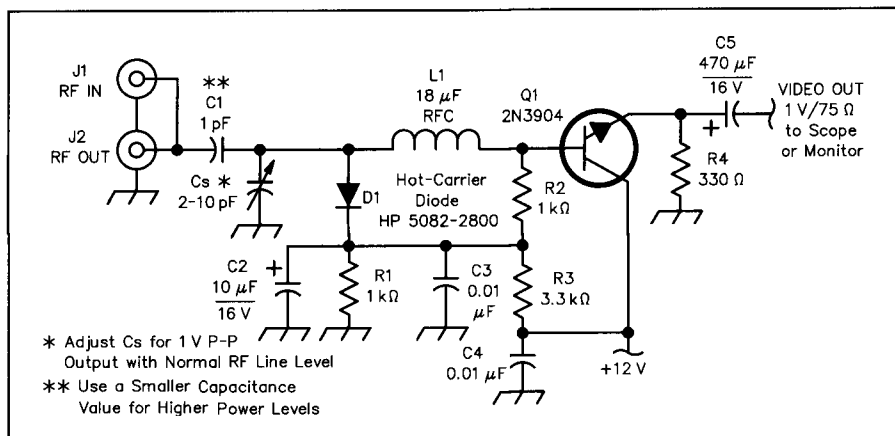


Figure 8—Schematic of a line (signal) sampler that can be used to directly drive a monitor (or RF modulator) with a low level of the transmitted video signal.

⁷Notes appear on page 42.

leakage through the TR relay is used to feed the converter (around 0 dBm for a peak transmit signal of 2 W). So biased, Q1 exhibits a loss of about 30 dB, so the mixer sees around -30 dBm or so (7 mV), a level it can handle. The exact levels encountered depend on relay leakage, shielding and individual layout, so some experimentation is needed to obtain satisfactory results.

For portable operation the station can be kept "bare bones" and the video-monitoring omitted, but make and verify all adjustments at the home station. Resist the temptation to tweak anything in the field without suitable monitoring or in response to reports from another station viewing the transmission. A small, battery powered TV set can be used with the converter. Use a relay or other muting circuit to kill the TV audio during transmissions. Opening the TV's speaker leads during transmit is probably the easiest method. Many TV sets have a headphone jack, and the speaker wires can be rearranged to use this jack for muting purposes.

Looking at You

A small CCD camera is a good video source. Such cameras come in a wide variety of configurations: color and monochrome cameras are available in sizes ranging from a one-inch cube to cased units measuring a few inches on a side. A small security camera is probably the best choice if you want to buy something ready-made, although you may want to make your own camera by mounting a PC board camera in a case of your choice. Black-and-white (B&W) cameras can be had for \$150 or less, and are best where low-light conditions are encountered, as sensitivities of less than 0.1 lux are readily available in low-cost units. Color cameras are preferred by most amateurs, but they cost more (\$235 up) and many of them require light levels of 5 to 10 lux for a decent picture. Color cameras also consume more power, an important consideration if you plan on battery operation. If possible, select a camera with C-mount interchangeable lenses. Cameras with adjustable irises are advantageous in situations where a lighting varies widely. Some smaller CCD cameras with electronic shutters can't cope with very bright light or specular reflections—they bloom or produce halos around bright sources. An iris helps here. Some BW CCD cameras can be helped by using a filter that absorbs red and near-infrared light, as the cameras are most sensitive to these wavelengths. A green, cyan or light-blue filter can improve skin-tone rendition, particularly when using tungsten light. (Such filters are usually unnecessary when fluorescent lighting, which has less red and more green and blue, is used.) Filters are available in standard sizes from the larger photo-supply houses. C-mount lenses accept 49-mm (a common size) or smaller filters, depending on lens size and threads.

In lieu of such filters, you can use a thin window of green or blue plastic mounted in

front of the lens, if the plastic is free of optical defects. If you can see sharply through the filter, it's probably okay for this application. Many small CCD cameras use 4-mm lenses. For station use, a "normal" lens (having a focal length of about the diagonal measurement of the CCD sensor) is probably best. This equates to 6 to 8 mm for a 1/3-inch sensor. A 4-mm lens is a wide-angle lens.

Connect the camera to your monitor and experiment with camera placement and the distance to the subject for best results. Some cameras are prefocused and best left alone if the focus is satisfactory. PC-board cameras are usually focused by moving the lens in and out, after loosening several tiny locking screws on the lens mount. Retighten the lens in the optimum position. Some fixed-focus cameras can't be adjusted easily.

Lighting

Natural light, tungsten and fluorescent light sources are useful, but with color cameras, a cast may result from certain light sources. Fluorescent light has a discontinuous spectrum, with a series of sharp peaks in the blue and green regions. Tungsten light has a continuous spectrum, but peaks in the near-infrared, and is deficient in the blue region of the spectrum. Such light produces a reddish-yellow cast and the infrared that's present affects the tonal rendering with B&W CCD cameras, which are very sensitive to the near-infrared. If you point the camera directly at even a dim tungsten light source, it will appear unnaturally bright and may even wash out completely. Faces appear chalky and pasty white. Foliage and plants appear white due to their high IR reflectance. Color CCD cameras usually have built-in filters to compensate for this effect, but B&W units generally do not. Also, most color CCD cameras have a *white balance* circuit that generally does a fairly good job of correcting for light-source imbalances. Use flat lighting and try to avoid high-contrast situations (>100:1 variations in light level or about five or six f/stops). Avoid deep shadows or specular highlights as much as possible. Every situation is different, so the best way to check video quality is to connect your camera to a monitor and observe the picture while using various light sources and placements. A mixture of fluorescent and incandescent light is usually the best approach when natural daylight is not available.

Antennas

Antennas are very important to the successful operation of any ATV setup. Simple quarter-wave whips and groundplanes are okay for short-distance use, R/C applications, or local links where coverage of a radius of 1 to 2 miles is all that is needed. For ranges up to several miles, simple antennas—such as 10 to 15-dB-gain Yagis, corner reflectors, or omnidirectional collinears are needed. Where ranges of 30 to 100 miles are desirable, high-gain antennas are a must, unless you have an ideal line-of-sight situation, in which case a 12 to 15-dB-gain

antenna may suffice. For a good ATV picture, you need a 30-dB S/N. A 20-dB S/N at the receiver produces a very snowy, although usable, image. Contrast this with 2-meter FM where an 8-dB S/N is comfortable, or with SSB where even 3-dB S/N is quite readable. You might say we need at least 20 dB better S/N than the 2-meter FM crowd does. Also, while 2-meter FM needs a receiver bandwidth of only about 12-kHz, fast-scan AM TV used on 440 MHz needs a bandwidth of 3 to 4 MHz. This is about 300 times as much bandwidth, with correspondingly 300 times (about 25 dB) more noise power. So, for comparable results, we're at a 50-dB or so disadvantage compared to the 2-meter FM operators.

Also, the bandwidth of the ATV antenna must be adequate to pass a 5-MHz-wide signal. Many Yagis designed for UHF DX work and SSB will not do this. There are Yagi antennas specifically designed for ATV; they have the necessary bandwidth for this purpose. Narrowband antennas lose video components of the transmitted signal. You'll obtain poor definition, weak or no color, and generally poor results when trying to use a narrowband antenna for ATV. Several antenna manufacturers and other companies sell antennas suitable for ATV use. Check the ads in *QST* for information on distributors carrying these products.

Summary

The three articles in this series have covered the basic hardware you need to get started in ATV. The converter, three-channel transmitter, a small B&W PC-board camera and the needed interfacing components can be had for \$250 to \$300—less, if a well-stocked junk box is available. That's pretty good—less than the cost of many 2-meter H-Ts.

The receiving converter is pretty straightforward and the transmitter is not much more than an AM transmitter with a wide bandwidth modulator and a subcarrier generator. We trust this series will encourage more amateurs to try this fascinating mode and help populate our UHF bands so we don't lose them to commercial services.

The transmitter and downconverter for the 902 to 928-MHz amateur band (see Notes 2 and 3) can be adapted to work up to 1300 MHz. Let's see more ATV activity and occupancy of these bands!

Notes

⁷Rudolf Graf, KA2CWL, and William Sheets, K2MQJ, "Get on 440-MHz ATV!—Part 1: A 440-MHz Downconverter," *QST*, Oct 1996, pp 36-40; Rudolf Graf, KA2CWL, and William Sheets, K2MQJ, "Get on 440-MHz ATV!—Part 2: A 440-MHz Transmitter," *QST*, Nov 1996, pp 37-39.

⁸PC boards, parts for the converter and transmitter described in this series, and cameras are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053. Contact them for details: tel 914-235-6611; fax 914-576-6051. Catalogs can be purchased for \$1 (refundable with the first order) and a #10 envelope bearing 75 cents First-Class postage.

⁹Video modulators are available from North Country Radio (see Note 8). **QST**