Enjoy video programming throughout your house with the Video Master video distribution system.

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EXOTIC HOME-ENTERTAINMENT containing VCR's, satellite receivers, laserdisc players, video games, security cameras, and more are certainly enjoyable. However, they often fall short in convenience. The Video Master adds that missing convenience; it lets you set up your own video network and watch any video source on any TV in your home.

The Video Master, described in this article, consists of a series of converters that place all your video sources on unused UHF channels and then combines them with normal TV channels (terrestrial or cable) into one cable. That one cable can then feed several TV sets for whole-house coverage. The desired video source is selected with the TV set's tuner. All of the TV's remote-control features are retained, and you'll be able to switch between any of the sources simply by changing the channel!

Keep in mind that it's illegal to insert unauthorized signals into any public cable system. An isolation amplifier, incorporated in the Video Master's design, prevents signals from feeding back into the cable system. *Do not omit the amplifier portion of the system for any reason.*

Figure 1 shows a block diagram of a typical system setup with the Video Master. It shows a TV antenna (or cable system), satellite TV receiver, VCR, security camera, video game, and laserdisc player, all feeding the Video Master. Notice that all inputs (except cable or antenna) are on Channel 3. There are five upconverters (1 through 5) and a buffer amplifier/power supply module, which supplies +12-volts DC to the upconverters.

The six outputs are combined with a splitter in reverse so that it acts as a signal combiner. The splitter feeds the combined output to all the TV sets in the sys-

tem. The combined output contains all terrestrial or cable channels (VHF 2–13, MID-BAND, UHF, etc.) in the original locations, plus five new channels—36, 39, 42, 59, and 61. Those five new channels carry the signals from the satellite TV, VCR, security camera, video game, and laserdisc player. Any TV on the system can select any signal source by tuning to its new channel.

A buffer amplifier and power supply module inputs the broadcast or cable channels into the system and prevents signals from being fed back to the antenna or cable system. The amplifier also provides about a 7-dB gain to overcome unavoidable losses in the combiner network at the output of the system. The power supply is fed by either 12–14 volts AC or 15–20 volts DC; it supplies +12 volts DC at up to 180 milliamperes to power as many as five upconverters. (The amplifier/power supply module requires about 30 milliamperes, and each upconverter module requires about 35 milliamperes.)

Block diagrams of the upconverter and amplifier modules are shown in Fig. 2. The upconverters consist of a preamplifier operating at 60–66 MHz, with 23-dB gain, and a two-pole bandpass filter between the amplifier and mixer. A double-balanced mixer combines the 60–66 MHz (Channel 3) TV signal with a local oscillator (LO). The LO is set to operate at a frequency 60 MHz below the low end of the desired output signal. For example, to obtain an output on Channel 39 (620–626 MHz), the LO must be at 560 MHz.

Several outputs appear at the mixer output: the original Channel 3 signal, the LO signal, and their sum and difference frequencies. A three-pole bandpass filter selects the desired output (the sum of LO + Channel 3) and rejects the difference frequency. (Theoretically, a double-balanced mixer produces no LO or Channel 3 output, but the mixer used here is not a perfect device, and those frequencies still appear.) The Channel 3 signal is severely attenuated, but the LO signal is suppressed by only 25 dB. Because the LO level must be about +7 dBm (decibels above one milliwatt) or about 0.3 to 0.5 volts rms at the mixer input, the LO appearing at the mixer output is still −18 dBm (about 30 millivolts rms). The desired Channel 39 signal is at about −34 dBm (approximately 4 millivolts rms). Therefore, the LO signal is about 16dB stronger than the desired Channel 39 signal, even using a balanced mixer and keeping the input signal level as high as possible (10 millivolts) to avoid generating excessive spurious signals. The LO signal can interfere with another channel 60 to 66 MHz lower (in this case, Channel 28).

If the LO signal is suppressed to less than half a millivolt, it causes no problems as long as it is placed outside an existing UHF channel. Because typically ten or fewer UHF channels can be received in any given area, ten or fewer new channels—or upconverters—will be needed. The upconverter channel outputs must be selected so as to

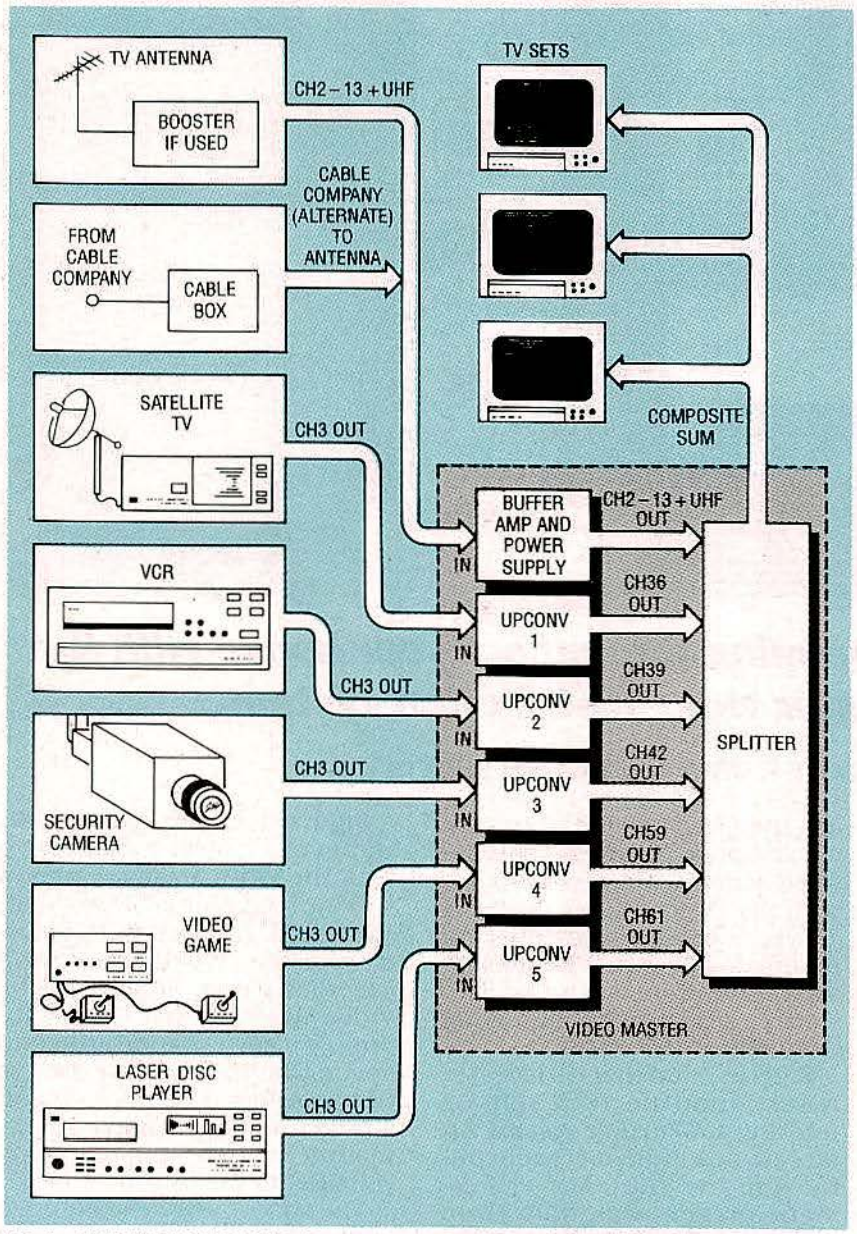


FIG. 1—THE VIDEO MASTER lets you convert Channel-3 outputs from many video devices to unused cable channels, combine them with your normal channels, and view them from any cable-ready set in your house, simply by tuning to the proper channel.

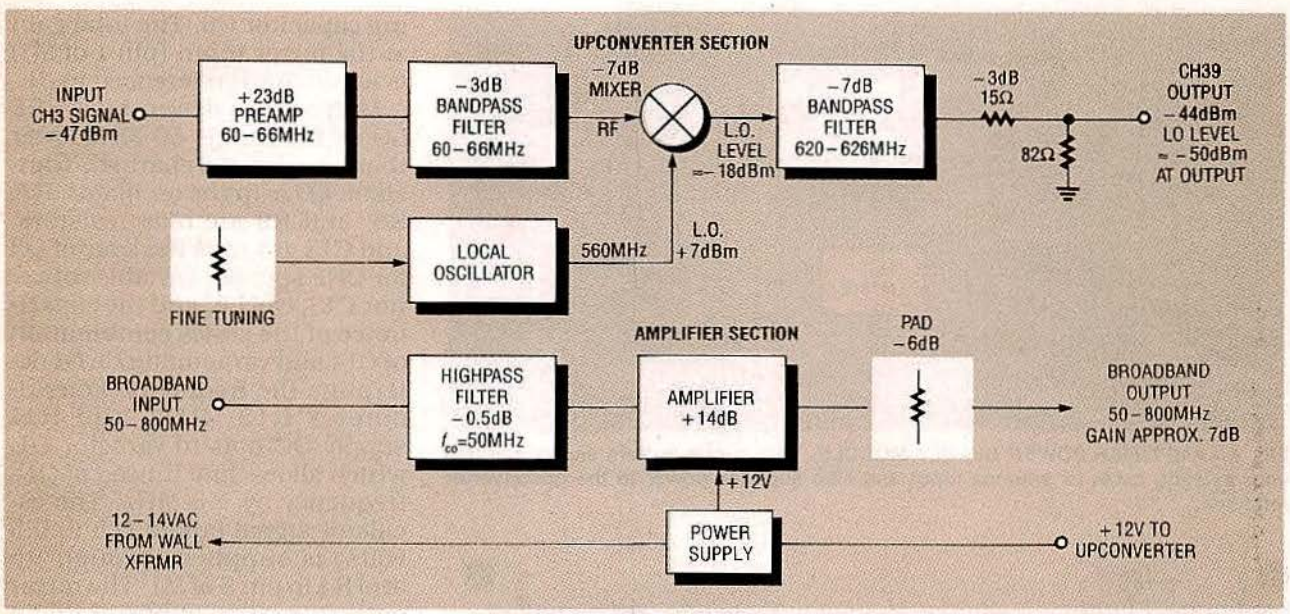


FIG. 2—BLOCK DIAGRAMS of an upconverter module and an amplifier/power supply module.

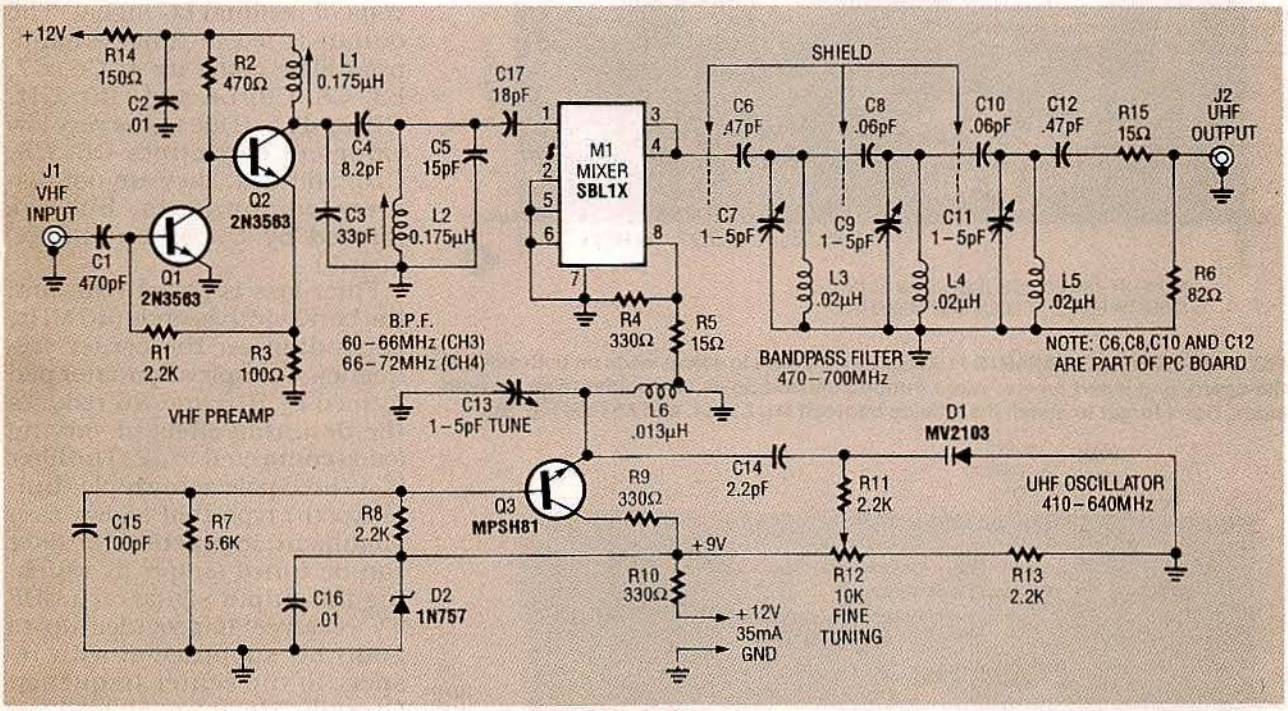


FIG. 3—VIDEO MASTER SCHEMATIC. This circuit inputs a VHF signal at J1 and converts and outputs it as a UHF signal at J2.

avoid placing the LO signal on top of an existing UHF channel. In our example, a Channel 39 upconverter output would have its LO at 560 MHz, and therefore it could interfere with Channel 28 and Channel 29. In an area where a UHF station exists on those channels, the upconverter should be moved up to Channel 41 or down to Channel 37 to avoid interference with Channel 28 or Channel 29. In general, do not select an output frequency 10 or 11 channels higher than our existing UHF channel or any UHF channel to be used by another upconverter in the system.

To reduce stray signal pickup and interference problems in general, individual upconverter and amplifier/power supply modules are used. That eliminates crosstalk problems, and simplifies shielding and circuit layout. The modular approach also lets you build only what you need, yet still allows future upgrades and expansion.

Circuitry

A schematic diagram of the upconverter is shown in Fig. 3, and its companion amplifier and power supply is shown in

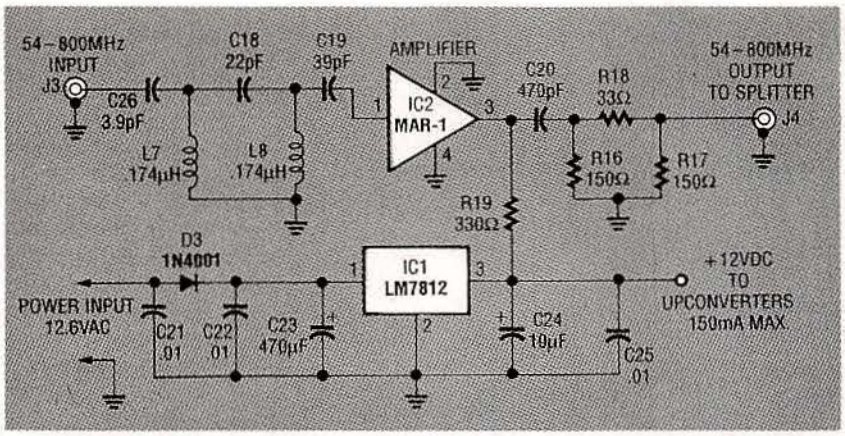


FIG. 4—AMPLIFIER/POWER SUPPLY MODULE. This circuit buffers and conditions your existing cable or antenna input and also supplies power to the upconverter modules.

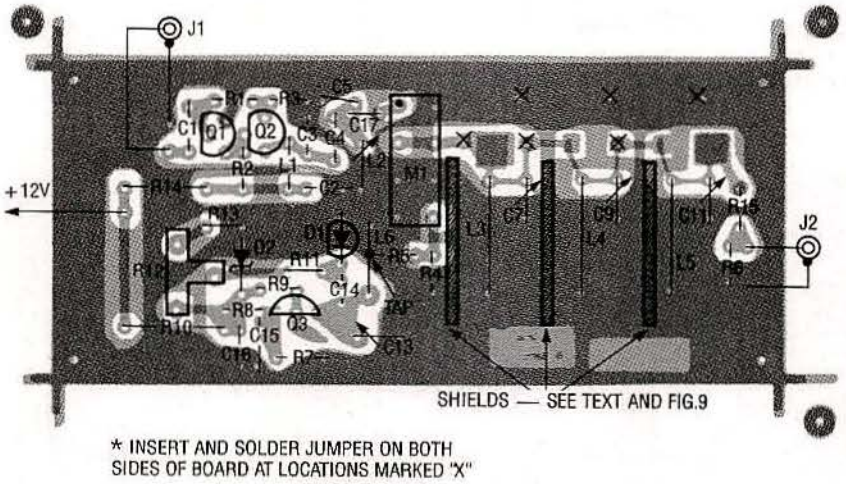


FIG. 5—UPCONVERTER PARTS PLACEMENT. Be sure to solder leads on both sides of the board, and insert jumper wires through unused holes and solder them on both sides. Don't forget to install the shields between M1, L3, L4, and L5 (see Fig. 9).

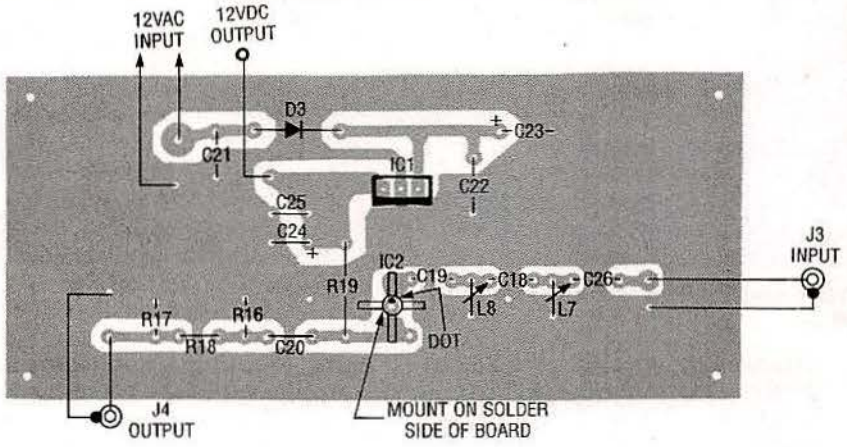


FIG. 6—PARTS-PLACEMENT DIAGRAM for the amplifier/power supply board.

Fig. 4. Channel 3 (VHF) input from a video device such as a VCR is supplied to J1. The signal level is assumed to be −47 dBm (about 1 to 2 millivolts). Capacitor C1 couples the input to an amplifier consisting of Q1 and Q2. The collector of Q2 feeds a filter with a 60–66 MHz passband. The filter components are L1, C3, coupling capacitor C4, L2, C5, and matching capacitor C6. The total gain at the mixer input (pin 1 of M1) is about 20dB referenced to J1.

Mixer M1 is driven by a UHF LO signal that is 60 MHz lower than the desired channel. Transistor Q3 is in the oscillator; R7, R8, and R9 are bias resistors, and C15 grounds the base of Q3 for UHF signals. Variable capacitor C13, coil L6, and the capacitance of the series combination of C14 and varactor diode D1 determine the frequency. Potentiometer R12, R13, and R11 supply DC bias to varactor D1, which allows fine tuning of Q1's frequency by ±3 MHz. The oscillator signal (about 0.3 to 0.5 volts) is supplied through R5 and R4 to pin 8 of M1. The mixer output appears at pins 3 and 4 of M1, where about 4 millivolts of desired signal (the output) is present, along with 25–30 millivolts of residual LO signal. The output is fed to tunable bandpass filter made up of C6, C7, L3, C8, C9, L4 and C10, C11, C12 and L5. (Due to the very low values of capacitors C6, C8, C10, and C12, they are not discrete components, but are formed by traces on the PC board.)

Filter loss is about 7dB, and the bandwidth is about 10 MHz, depending on the center frequency. A simple attenuator pad formed by R15 and R6 reduces the detuning effect of varying loads connected to J2. The filter is a three-pole zero-ripple (Butterworth) type that allows easy alignment. In practice, the filter can be tuned simply by watching the output signal on a UHF TV receiver. It provides up to 50dB LO suppression with respect to the center frequency. Overall gain from J1 to J2 is about +3 to +6dB. That allows for loss in combining the output of J2 with the outputs of additional converters.

Figure 4, the amplifier-section schematic, shows that the antenna or CATV input is applied to J3. A high-pass filter formed by C26, C18, C19, L7, and L8 attenuates unwanted signals (such as shortwave, CB, amateur, and AM) below 50 MHz. A monolithic microwave integrated circuit (MMIC) am-

plifier, IC2, has a broadband gain of about 14dB. Resistor R19 provides DC bias to IC2, and C20 couples the amplified output to resistors R16, R17, and R18 (which sets the total gain to about +7 to 8dB) and to J4. The amplifier compensates for the inevitable loss in the signal-combining network connected to J4.

A 12.6-volt AC wall-mounted transformer feeds components C21, D3, C22, and C23. Those components supply approximately 16-volts DC to the input of an LM7812 regulator (IC1), which supplies 12-volts DC to the rest of the circuit. (If desired, +15 to +20 volts DC can also be introduced to the supply. In that case, D3 would guard against reversed DC power-input polarity.)

Construction

The PC board for the upconverter is double-sided, and the board for the amplifier and power supply is single-sided; foil patterns are provided for both. Parts-placement diagrams for the two boards are shown in Figs. 5 and 6, respectively. Do not change the PC layout, because filter characteristics are dependent on it. PC boards and complete parts kits are available from the source given in the Parts List.

Although the upconverter boards are double-sided, they are not through-hole plated. Therefore, solder all component leads on both sides of the board wherever there is copper foil on both sides. In addition, you must place grounding jumpers in all holes marked with an "X," and solder them on both sides of the board to connect the top and bottom foils. Short lead lengths are important in RF projects because long leads can act as antennas. Also, mount all components snugly against the circuit board and clip their leads close to the board.

Although it would be possible to integrate inductors L3, L4, L5, and L6 into the PC board, the resulting printed inductors would have Q values that are too low, and there could be stray coupling and shielding difficulties. A high value of Q is necessary for L3, L4, and L5 to achieve narrow filter bandwidth, and for L6 to stabilize the oscillator. Those coils are made from lengths of No. 18 AWG wire as shown in Fig. 7.

Note that shields—small scraps of G-10 double-sided PC-board material from 0.020- to 0.062-inch thick—must be soldered after standing them on

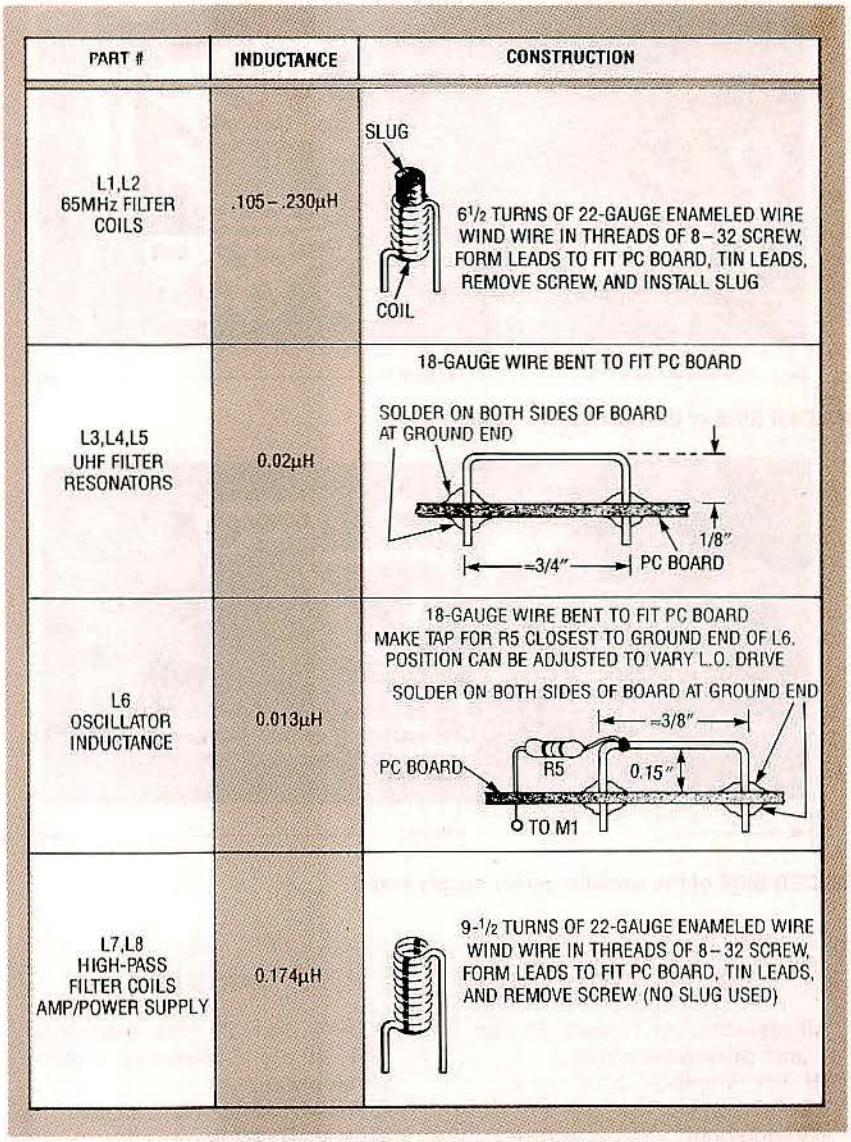
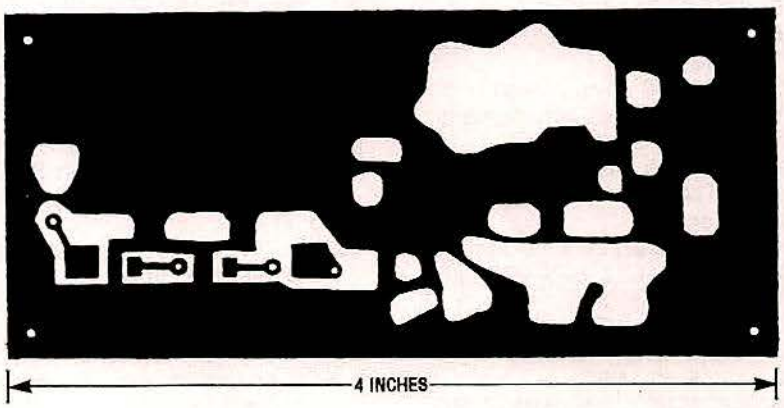
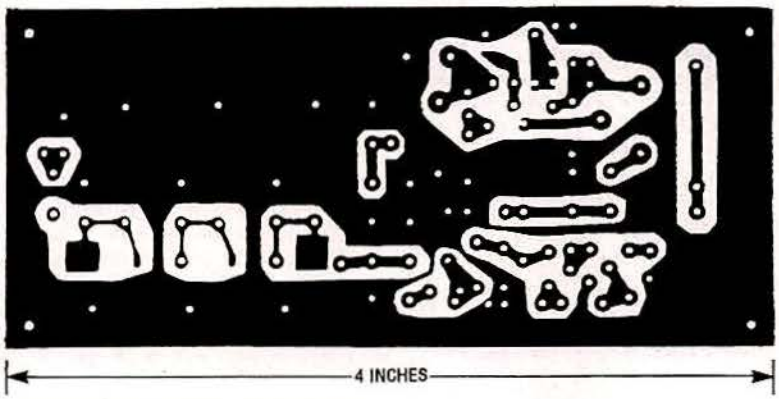


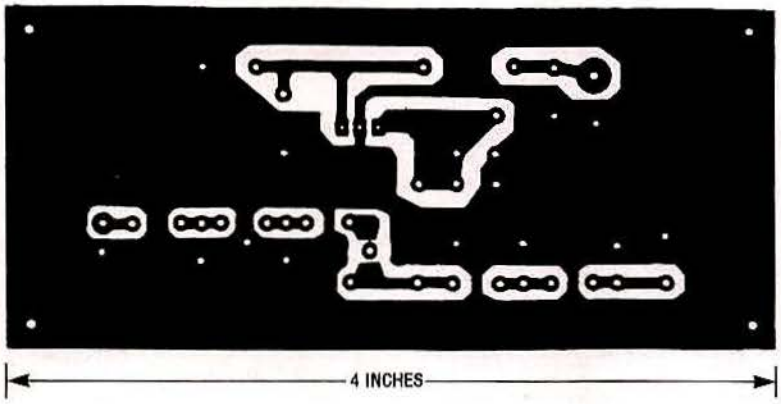
FIG. 7—COILS L1–L7 are made according to these instructions.



COMPONENT SIDE of the upconverter board.



SOLDER SIDE of the upconverter board.



SOLDER SIDE of the amplifier/power supply board.

edge on the top ground plane of the upconverter PC board between M1, L3, L4, and L5 in the locations shown in Fig. 5. The shields are necessary for proper filter performance because they keep down spurious outputs—especially the LO residual leakage. The shields must be well soldered to the top of the PC board.

Mount each converter in its own enclosure. A suitable case is included with the previously mentioned upconverter kits. Suitable connectors are F, BNC, TNC, or SMA—do not use UHF or RCA connectors. Figure 8 shows a suitable packaging scheme for the upconverter board and the amplifier board. Do not omit the three shields in the upconverter filter section, as shown in the photo of the board in Fig. 9. Figure 10 is a photograph of the amplifier/power supply board.

Figure 11 shows one way to mount several modules together to make up a system. The module outputs all connect to the "outputs" of a passive split-

PARTS LIST

All resistors are ⅛ watt, 5%, unless otherwise noted.
R1, R8, R11, R13—2200 ohms
R2—470 ohms
R3—100 ohms
R4, R9—330 ohms
R5, R15—15 ohms
R6—82 ohms
R7—5600 ohms
R10, R19—330 ohms, ¼-watt
R12—10,000 ohms, potentiometer
R14—150 ohms, ¼-watt
R16, R17—150 ohms
R18—33 ohms
Capacitors
C1, C20—470 pF, ceramic disc
C2, C16, C21, C22, C25—0.01 μF, ceramic disc
C3—33 pF, 5%, NPO
C4—8.2 pF, 5%, NPO
C5—15 pF, 5%, NPO
C6, C8, C10, C12—Part of PC board
C7, C9, C11, C13—1–5 pF trimmer
C14—2.2 pF ±0.5 pF, NPO
C15—100 pF, 10%, NPO
C17—18 pF, 5%, NPO
C18—22 pF, 5%, NPO
C19, C26—39 pF, 5%, NPO
C23—470 μF, 25 volts, electrolytic
C24—10 μF, 16 volts, electrolytic
Semiconductors
IC1—LM7812 12-volt regulator
IC2—MAR1 MMIC
D1—MV2103 varactor diode
D2—1N757 9-volt Zener diode
D3—1N4001 diode
Q1, Q2—2N3563 NPN transistor
Q3—MPS H81 NPN transistor
Other components
L1, L2—6½ turns No. 22 AWG enameled wire wound on 8-32 screw with 8-32 ferrite slug (see Fig. 7)
L3–L5—0.02 μH (¾-inch No. 18 AWG wire, see Fig. 7)
L6—0.013 μH (½-inch No. 18 AWG wire, see Fig. 7)
L7, L8—0.174 μH (9½ turns No. 22 AWG enameled wire wound on 8-32 screw)
M1—SBL1X mixer
J1–J4—chassis-mount F-connector
Miscellaneous: PC boards, one shielded enclosure per module, hardware, feedthroughs or bushings for power inputs and outputs, 12.6-volt AC wall transformer, two feet of 22-gauge enameled copper wire, two feet of 18-gauge tinned copper wire, 2- or 4-way splitter, 75-ohm cable, solder

Note: The following items are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804:

- **Amplifier/power supply kit (includes case, hardware, connectors, PC board, and all parts)—$29.50**
- **Upconverter kit (includes case, hardware, connectors, PC board, and all parts)—$34.50**
- **Four-way splitter—$5.50**
- **12.6-volt AC wall transformer—$ 9.50**

Please add $3.50 S&H (foreign orders $5.00) to any order. NY residents must add sales tax. For a catalog of other kits, please send $1 (refundable on next order) or SASE (52 cents postage) to North Country Radio at the above address.

ter. A passive splitter can be used as a combiner simply by running it backwards. That won't work for an active, amplified splitter.

The upconverter modules have a 3-dB gain, which is adequate for compensating for splitter loss. Because most video devices have an RF output of about 3dB above 1 millivolt, approximately 1 millivolt of UHF signal will appear at the system output for each channel, assuming the use of a four-way splitter and three upconverters. The cable level should be around 1 millivolt per channel, which will give about 50dB or better signal-to-noise ratio for the average TV receiver. Levels lower than 200 microvolts might yield a snowy picture. If necessary, the system output can be run through a distribution amplifier. Remember to terminate all unused splitter ports with 75-ohm terminating resistors.

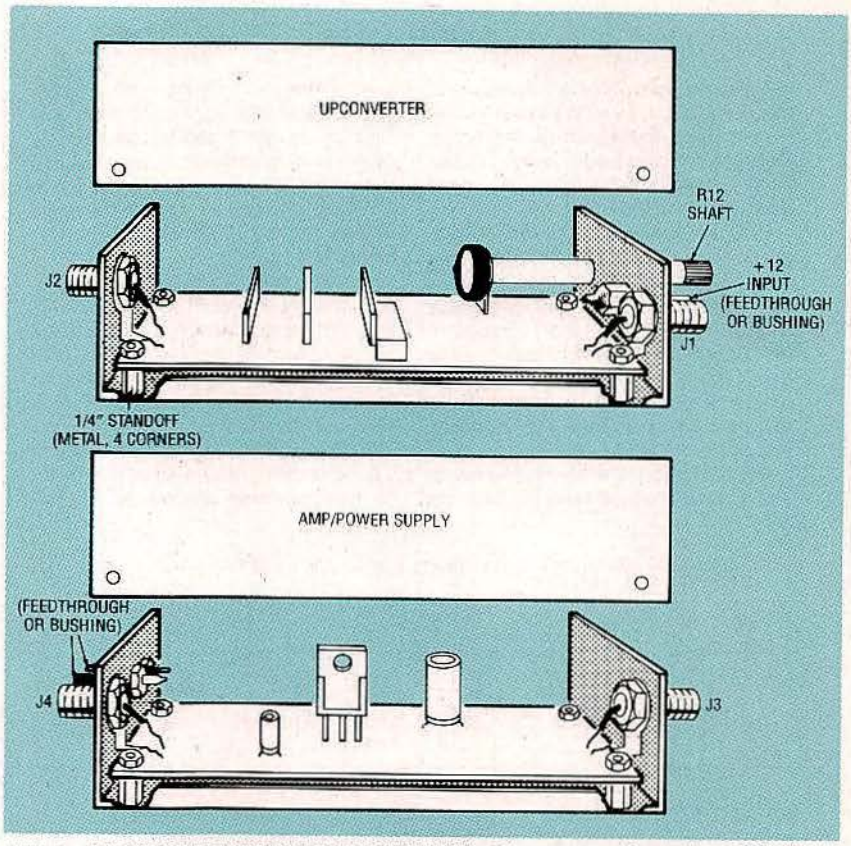


FIG. 8—SUGGESTED PACKAGING SCHEMES for the upconverter and amplifier/power supply boards.

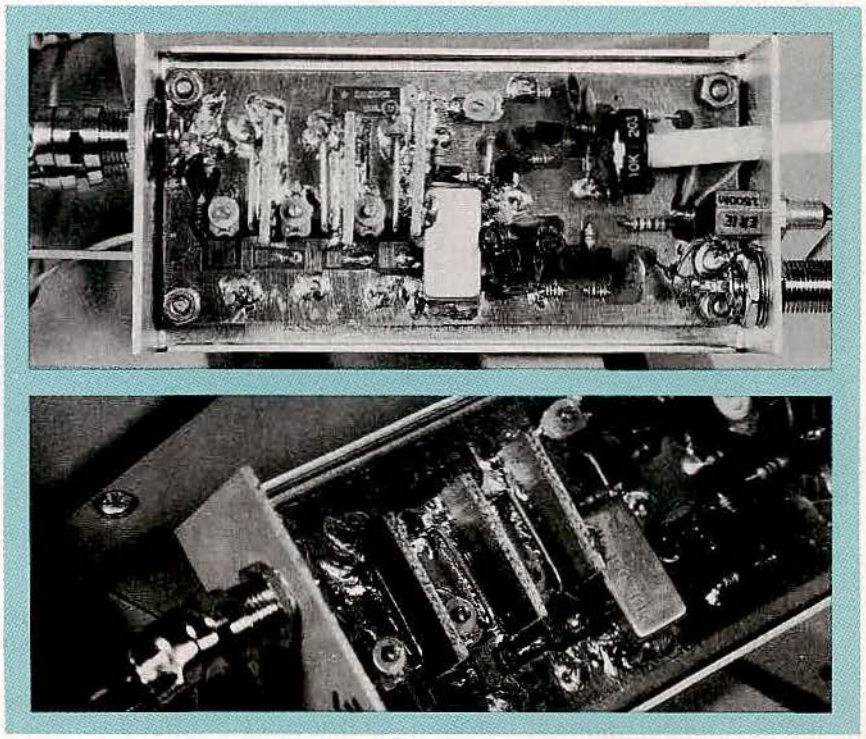


FIG. 9—UPCONVERTER BOARD. Note the shields, made from scraps of double-sided PC board material, that are placed between M1, L3, L4, and L5.

Test and alignment

Alignment of the completed unit requires a video source on Channel 3 (your VCR will do) and a digitally tuned TV set. A frequency counter will also be helpful in this procedure.

First check out the amplifier/power supply. Connect a source of 12 to 14 volts AC, of at least 250 milliamperes to the junction of C21 and D3, and connect the remaining lead to ground—a plug-in wall transformer is recommended. Alternatively, a DC source of 15 to 20 volts can be used, with the positive lead to the C21-D3 junction, and negative lead to ground. Regardless of the supply you use, verify that there is 15 to 20 volts DC across C23.

Next check for +12 volts at the junction of IC1, C24, C25, and R15. If there is less than 11.5 volts or more than 12.6 volts, check to see if IC1 is defective or improperly inserted in the PC board. Check to be sure that IC1 does not get hot. If all tests are passed so far, check for +4 to +7 volts at pin 3 of IC2. Next check for infinite resistance from the center pin of J3 to ground. Next, check the resistance from J4's center conductor to ground; it should be about 80 ohms. Mount the board in a case, apply power, and connect a TV receiver to J4, and the antenna to J3. Normal

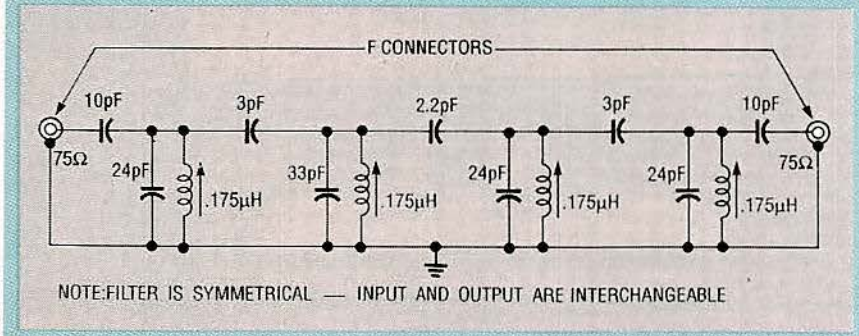
CABLE BOXES

There are many different types of cable boxes, but as far as the Video Master is concerned, there are only two types. One type contains a built-in video modulator and its output is spectrally clean enough for the Video Master.

However, many cable boxes are simply RF converters, and there are other frequencies mixed in with the Channel-3 or -4 output. You can easily test this by changing channels on the TV's tuner. If the TV can receive any channels other than Channel 3 (or 4), you could have problems with the upconverter modules that will show up as lines, ripples, noise, and beats in the picture.

If you have any of those problems and you're sure that no stray signals are leaking into your system, build the filter shown here. It's designed to pass only Channel 3, but it can be retuned for Channel 4. Its capacitors are all silver mica or NPO ceramic. The coils are 0.175 µH, and can be made in the same way as L1 and L2 in the upconverter modules.

The filter can be built on a scrap piece of G-10 copper-clad PC board material. It should be mounted in a shielded box and provided with F connectors for best results. It is aligned by peaking the coils for maximum signal on Channel 3. A VCR can be used as a signal source. The filter should be inserted between the cable box and the input connector on the appropriate upconverter. Ω



This filter will remove all signals except Channel 3 (or 4) from the output of your cable box.

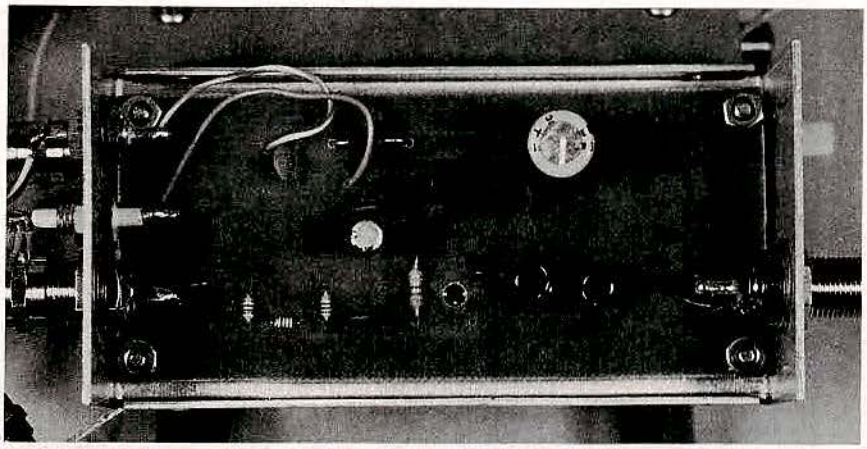


FIG. 10—AMPLIFIER/POWER SUPPLY. This board is mounted in the same type of case as the upconverter modules.

TV reception should result, with no loss of picture quality. If RF test equipment is available, measure the gain from J3 to J4. About 7 to 8dB should be obtained at 450 MHz (UHF), and slightly more on VHF (100 MHz). That completes the amplifier/power supply tests.

The upconverter board is tested as follows: After the board has been visually checked for shorts, solder bridges, and correct component placement, install the board in its case. Connect a Channel-3 source to J1 and connect a TV receiver to J2. Use 75-ohm cable. Apply power to the 12-volt input (the junction of R10 and R14), and check for the following voltages:

- Junction of D2 and R10—+8.4 to 9.5 volts
- Wiper of R12—+3 to 9 volts depending on setting of R12
- Junction of R11 and D1—+3 to 9 volts depending on setting of R12
- Emitter of Q3—+6 to 7.5 volts (adjusting C13 should vary the voltage by ±0.1 volt—this verifies that Q3 is oscillating)
- Base of Q3—+6 to 7.5 volts (adjusting C13 should vary the voltage by ±0.1 volt—this verifies that Q3 is oscillating)
- Emitter of Q2—+1 to 1.2 volts
- Base of Q2—+1.8 to 2.1 volts
- Collector of Q2—+8.5 volts (typical)
- Pin 8 of M1—0.3 to 0.5 volts RMS (this test is optional, and can only be done with an RF voltmeter)

Tune the TV receiver to the UHF channel on which you would like the upconverter to produce a signal. Set the slugs in L1 and L2 halfway in the coil winding. Set C7, C9, and C11 so that their plates are halfway engaged, and C13 fully engaged. Set R12 to mid-position. Turn on the source connected to J1. Slowly rotate C13 with a plastic alignment tool; at several points the TV set should exhibit a response of some kind. (If you have a frequency counter, connect it to pin 8 of M1 and set C13 for the correct oscillator frequency.) When you get a response, you might see a very weak picture, but at first you will probably only hear audio. Note the position of C13. Now look for other responses; the correct one will be where C13 is set at greater capacitance (more of the plates engaged).

The oscillator can produce an output either on the high or low side of the desired channel—you want the low side, otherwise the converter output will have picture and sound frequencies inverted from the usual positions. Next, slowly adjust C7, C9, and C11 for best picture and sound. Now go back to L1 and L2 and adjust for best picture quality as well as sound quality. Readjust C7, C9, and C11 for the best picture and sound. Repeat any alignment as needed.

The adjustment of trimmer

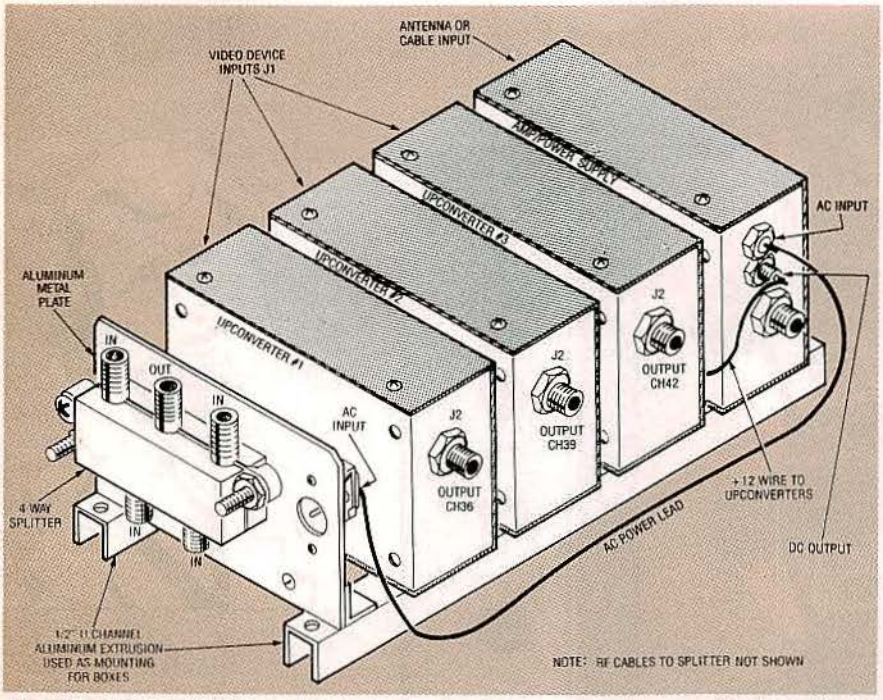


FIG. 11—ALL OF THE MODULES for the prototype Video Master are mounted together on a pair of aluminum rails, with everything feeding into a 4-way splitter mounted on one end of the assembly.

capacitors C7, C9, and C11 is very critical. Some difficulty might be experienced at first, "getting in the ballpark," since the bandpass filter is quite sharp (10 MHz), and it will have high attenuation when misaligned. Once you get a picture of any kind, the rest is easy. If the unit appears to work but the TV set tuning is critical, the picture "grainy," or the color poor, make sure that C13 is set on the proper side. (As mentioned before, there will be two settings, and the lower frequency is correct.) When aligned, the picture on the selected UHF channel should be of excellent cable quality.

After alignment is complete, verify the fine-tuning adjustment R12. Normally R12 is left in the halfway position, and adjusted only to touch up the frequency setting.

The upconverter can now be installed in your TV system, and should operate reliably with no attention from you. For overall system stability, we recommend leaving the upconverter system on all the time, hence no switch is installed in the system. Ω