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TC70-1 70 CM ATV TRANSCEIVER

USERS MANUAL

The TC70-1 transceiver is designed to provide over 1 Watt continuous duty peak envelope power (sync tip) of video modulated RF in the 70 CM (420-450 MHz) amateur band. Any licensed Technician class or higher Radio Amateur may operate this transmitter in accordance with 47 CFR part 97 of the FCC Rules and Regulations. The TC70-1 accepts U.S.A. standard composite video (1 volt pk-pk) from any source such as color or black and white TV cameras or camcorders, VCRs, or computers for transmission. Audio from these sources or a low impedance dynamic mic is also transmitted on the 4.5 MHz sound subcarrier. A tuneable downconverter tunes the whole 420-450 MHz band down to your TV set on channel 3 or 4.

PLEASE read through this manual before plugging in an cables and attempting operation. Each connector and control is described here to enable your proper hookup and operation. Also the unique video practices associated with ATV and the 70 CM band are described.

REAR PANEL:

POWER INPUT JACK. A 4 pin plug and 3 ft long #18 cable is provided for connection to your source of 12 to 14 Vdc. Pin 1 is ground (black) and pin 2 (red) is +. The TC70-1d works best from a well regulated voltage source with leads no longer than necessary. The transmitter is set up by us with a regulated 13.8 Vdc supply. Do not exceed 15 Vdc input. There is a 16 v zener which should blow the fuse if this voltage is exceeded or the supply leads get cross connected, but semiconductors have been known to protect fuses. Any ripple or noise on the DC line may be seen in the transmitted video. The Radio Shack 22-120 regulated power supply will run both the TC70-1d and camera.

2 AMP FUSE INSIDE. The TC70-1d itself draws .5 Amp in transmit, but since color cameras can draw up to an Amp, a 1.5 or 2 Amp 3AG fuse should handle both.

TV The downconverter output is at this jack during receive for connection to your TV receiver antenna input. Run a 75 Ohm coax with F connectors. Radio Shack has cables made up in various lengths (15-1530). If your TV does not have a 75 Ohm coax input, use a balun at the TV (15-1140). Tune the TV to channel 2, 3 or 4 depending on which ever is weakest or not on the air in your area. With the TC70-1d still off, fine tune the TV set, with the AFC off, for all snow and no adjacent channel feedthru. Now turn on the TC70-1d and slowly tune the REC TUNE knob for the best picture from a known close by ATV station. Once you have a picture, rotate your antenna for least snow or strongest picture. Then ask the ATV transmitting station to swing his antenna for the strongest picture. It's best to coordinate the tuning and antenna rotation on 2 meter FM. The most popular ATV coordination frequencies are 144.34, 144.90 and 146.430 MHz simplex. Select the one that does not have a 3rd harmonic within the video passband on 70 cm. The video transmitting station then talks to you on the sound subcarrier, and the receiving stations talk back at the same time (full duplex) on 2 meters.

TO MONITOR. This output provides composite video of your demodulated RF from the antenna output during transmission periods to enable you to best adjust the video gain, set focus and lighting, etc., rather than a distant station describing these back to you on 2 meters. In receive it outputs your selected 10 pin or phono jack video input to enable your setting up the picture on the monitor as you receive another station on the TV. It is also available thru the 10 pin camera connector pin 3. Use a RCA plug shielded cable to connect to your video monitor or VCR video in. If your TV receiver does not have a video input, the Radio Shack 15-1273 RF Modulator can take the composite video and modulate it up to channel 3 or 4 to make your TV set into a monitor.

Attempting to monitor off the air with another TV set at the same QTH most often gives false indications due to overload and reflections. Even receiving the 2nd harmonic 40 or more dB down around channel 80, or on cable channels between 57 and 60 can give an erroneous indication of transmitted picture quality. Only the monitor output will be accurate.

50 OHM 70 cm ANTENNA. A UG21 type N plug is provided to attatch to low loss .5" size 50Ω coax. Losses at 70 cm are very high in transmission lines. We suggest using the foam filled types (3.5 dB/100') such as Belden 8214, or semi rigid (2.5 dB/100') Belden 9913. Put the connector together properly. See ARRL HandBook Chapter 37. The type N connector has good moisture resistance and low loss at UHF but use two layers of vinyl tape or coax seal on all outside connections to prevent moisture contamination. The antenna and feed line are the most important part of your ATV system, and therefore the last item to just try and get by with.

Take great care with preparing connectors and cable. On initial turn on, do not transmit more than 10 seconds if the reflected power is more than 10% (.15 W) or 2:1 VSWR. You could damage the final or modulator transistor. Also, VSWR or being too near your antenna can cause RF interference in your camera or buzz in the audio.

Use a good resonant broad bandwidth 70 cm antenna such as the 15 element Quagi described in the ARRL HandBook Chapter 33 or commercially made antennas like the KLM 440-6X, 440-10X, 440-16X, or circularly polarized 435-18C & 435-40CX or Isopole omni. Do not be tempted to just try it out with a rubber duckie, 2 meter antenna, or other antenna not specifically designed for the video carrier frequency. Place the antenna as high as practical, at least above the trees or roof tops. See the section on dx vs. power vs. gain on page 4.

AUDIO INPUT. High level line audio usually from the same source as plugged into the companion Video input is plugged into this jack using another RCA phono plug shielded cable. Minimum level is .1 v pk-pk into a 10K load. The level is controlled by the audio gain knob on the front.

VIDEO INPUT. This is an alternative composite video input to the 10 pin camera connector on the front panel. It is selected along with the rear audio input when the front panel switch is in the video position. This input accepts any standard NTSC composite video into 75Ω from cameras, VCRs, computers, SSTV or RTTY converters, home satellite converters, etc. Use RCA phono plug shielded cable (Radio Shack 15-1535).

FRONT PANEL:

CAMERA jack. The EIA"J" 10 pin connector is found on most color cameras made for VHS type portable VCRs. If you have a camera made for Beta VCRs, different plug, or not sure of the pin out, use the RCA phono jacks on the rear panel. Consult your camera or mating VCR literature, manufacturers service center, or place that you bought it for pin out compatibility before plugging it in. Most cameras have an AC adaptor with RCA plugs, or use the VCR video and audio output jacks to the TC70-1d rear connectors.
The following pins are active:

1. Video input
2. Video ground return
3. Video monitor output
4,5,6 open
7. Mic audio input
8. Audio ground return
9. DC power ground
10. +12 to 14 Vdc out

CAMERA ON switch. This switch turns on the applied +12 to 14 Vdc to camera connector pin 9. It saves vidicon life when the TC70-1d is just in the receive mode for long periods of time to have it off. Make sure your camera can accept the voltage from your power source before turning it on. Most cameras have a regulator in the camera, but some have it in the companion VCR.

CAM/VIDEO switch. It selects video and audio from the rear panel RCA jacks in the Video position, and from the 10 pin camera connector in the Cam position.

VIDEO GAIN control. This sets the white level or depth of modulation of the selected video source. The knob should be slowly increased clockwise just to the point of white smearing or blooming as seen on an external video monitor, and then backed down a little. The viewfinder in a color camera can also be used if it can accept external video into it, as some do for VCR playback. If you do not have any kind of monitor, you might try having a distant ATV receiving station describe your picture back to you over 2 meters. See monitor output paragraph.

AUDIO GAIN control varies the audio applied to the subcarrier from the 10 pin camera (7) in the camera position, or from the rear panel audio input RCA phono jack in the video position. This control also varies the mic audio and is mixed in the subcarrier generator.

MIC jack accepts any low Z dynamic or low Z Amplified electret mic in the range of 100 - 600 Ohms with a mini plug. Mic audio is active at all times and mixes with the camera or external audio inputs to enable greater pickup, commenting while running video tapes, etc. Mikes must have a shielded cable to prevent RF pickup hum and buzz. Some electret and Amplified mics are very susceptible to RF pickup and may need the addition of a small 220 pF disc cap (RS 272-124) directly across the mic element. Presently Radio Shack makes 3 different replacement remote-control omnis for portable recorders (33-2001, -1060, & -1054) that work well and provide the "push to look" plug also. The 33-2001 has a wind screen which is preferred for portable work. The unidirectional 33-986 is used for full duplex to minimize speaker feedBack.

PTL submini jack. Push To Look is like push to talk only with video. Grounding the tip keys the transmitter.

RECEIVE TUNE control varies the varicap voltage in the VCO in the GaAsfet downconverter between 420 and 450 MHz in receive plus some overlap to accommodate conversion down to TV channels 2, 3 or 4.

XMIT/REC switch. It is in parallel with the PTL jack. The red lamp above this switch will light whenever you are in the transmit mode.

POWER ON switch turns on the applied +12 to 14 Vdc to the TC70-1d. If the green light does not come on, check the internal fuse and the reason for it to blow before replacement. If the leads were reversed or an overvoltage condition and fuses keep blowing, check the 16 Volt 1 Watt zener at the fuse holder solder lug for a short and replace if necessary .

OPERATING NOTES: ATV practices are somewhat different from the other bands and modes. Since we must use directional antennas to make up for the 26 dB higher noise floor difference compared to NBFM due to bandwidth (15 kHz vs. 3 MHz), the probability of someone pointing their beam at you while at the same time you at them and calling CQ is very low. This is why many ATV contacts are initiated by calling or listening on an area 2 meter FM simplex ATV coordination frequency (146.43, 144.34, 144.90 MHz most popular).

Two meters, even for FM, has about 9 dB less path loss than 70cm so that all possible ATVers can be received on 2 meter FM using just an omni antenna. You will find with experience the correlation between 2 meter simplex and 70cm ATV. It is much easier for all local ATVers to monitor a squelched 2 meter FM simplex channel than to try tuning and swinging the 70cm beam looking for sync bars or listening to TV speaker noise. Once another ATVer comes up on 2 meters, you can roughly swing the beams on each other before turning on the ATV transmitter. Then, if the picture is better than 20% snow, the video transmitting station can talk on the sound subcarrier, and all those receiving him can talk back at the same time on 2 meters (full duplex) to comment on picture content, etc. Others listening to the 2 meter channel are often hooked into ATV this way. You can also run full duplex audio and video with another ATV station on 33 or 23 cm.

It is more fun as time goes on to have many hams put their families, other hobbies, and varied interests on the screen. Let others know your 2 meter ATV freq. by publishing in local radio clubs, contact your local ARRL Scm, or pick a night and time to start an ATV net. The TC70-1d is portable enough to give a little demo at your local radio club

IF YOU BELIEVE THE TC70-1d ISN'T WORKING, please call first and describe the problem or ask any questions you might have. It will save us both time if we suggest some things to try that may have been over-looked, or for us to better evaluate the problem. Check all cables and connectors, power supply voltage and VSWR. The TC70-1d can be repaired by us for $40 plus parts cost in a few days if we believe the problem is customer caused, or only your shipping cost to us if we determine that it was due to our workmanship and materials within a reasonable time and given circumstances. Include with the unit your name, call, UPS shipping address, and a description of the problem. It will be sent back UPS COD if we determine the problem was customer induced or no change if our fault. If you prefer the repair charged to your Visa or Mastercard, include the card number, expiration date and name exactly as printed on the your card. There is no other warranty expressed or implied. We believe this policy is more realistic than the usual 90 day warranty other amateur manufacturers have since various parts have different expected lifetimes.

DX vs. POWER vs. ANTENNA GAIN. The >1 Watt output of the TC70-1 was chosen to provide an easy low cost entry into the world of ATV, but at the same time give flexibility to all the applications that hams might put the equipment to. One Watt connected to KLM 440-6X antennas for short distance video up to 8 miles with low battery drain public service applications is ideal. But for greater distance or areas of high path attenuation, it's output is matched for the best linearity drive region of RF Concepts 440 Mini Amp (15 W) or Mirage D26N (50 W) amps. The primary design difference between these amplifiers and others is the addition of various values of capacitors on the transistor bias and collector supply lines to keep the applied voltage constant under the high current swings to 5 MHz of the AM video envelope. Without these caps, the color and sync become distorted.

While it is almost impossible to predict actual ATV DX due to different terrain and conditions, the line of sight snow free picture distance can be calculated given all the controllable factors. We must know the transmitter peak envelope power (p.e.p. - sync tip), coax loss, and antenna gain over a dipole. At the receive end, we must also know the system noise figure and bandwidth. The chart below assumes the TX70-1 transmitter, TVC-4G GaAsfet downconverter or TC70-1d connected to a good TV set with 3 MHz IF bandwidth, 3 dB loss in coax at both ends, and snow free defined as a carrier to noise ratio of 40 dB (about 200 microvolts).

The distances in miles are shown in the order of 1.5/15/50 Watts which is the TC70-1 by itself , driving a RFC 440 Mini Amp (15 Watt) or Mirage D26N (50 Watt) linear amplifier. To find the possible DX under line of sight conditions find your antenna model or equivalent gain across the top. Then go down to the receive ends antenna or gain. Now read the miles that corresponds to your transmit power level.

The distance miles are in the order of 1.5/15/50 Watts.

XMIT.	3 dBd Ground Plane	9 dBd F718x 440-6X	16 dBd gain FO-25
REC.			
Gnd plane	2/6/11	4/12/21	8/26/48
440-6X	4/12/21	8/23/42*	16/52/95
FO-25	8/26/48	16/52/95	36/115/210

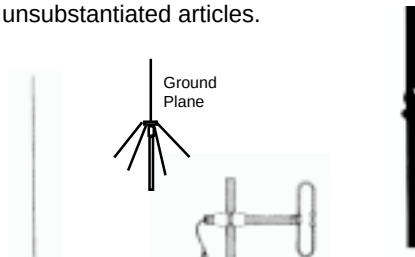
The purpose of the DX chart is to enable you to better figure what is needed in your system to have the best chance of getting good pictures where you want them. This is especially important to repeater owners or those setting up for a public service event to figure the expected area of coverage. The DB Products DB420 is a popular high gain broadband omni exposed dipole vertical used at single antenna/duplexer inband repeaters - two Diamond F718x antennas with >20 ft separation is also used. If a repeater is running 50 Watts to a DB420 or F718x omni, it could be snowfree to a station 42* miles away using a 440-6X beam. The distance will double or half with each 6 dB change. For instance if you mounted a Mirage KP-2 GaAsfet preamp at the antenna to save the 3 dB coax loss and went to dual beams for 3 more dB gain, you would be able to see a station of the same power and antenna at the same picture to noise ratio twice as far away, or one P unit stronger at the same distance. 3dB more gain from dual beams puts your transmit DX 1.4 times farther. A simple starter antenna for home or portable is the ground plane you can make yourself - see ARRL Handbook pgs 20.55 to 20.57.

Obviously, putting most of your time and money into the antenna system pays off in both transmit and receive. Adding more power does nothing to improve the receive DX. If you have one of our GaAsfet downconverters (TVC-2G, TVC-4G, or TVCX-70) you have a low noise figure (≈1 dB) and sufficient gain (≈25 dB) to put your receiving system at the noise floor.

The theoretical noise floor for a 3 MHz wide 70CM ATV system with a perfect 0 dB noise figure is .8 microvolts (-109 dBm). So adding another preamp at the shack will do nothing but pump up your AGC on noise making you more susceptible to intermod and overload interference without improving the sensitivity. Only changing to lower loss coax or adding a good quality GaAsfet preamp at the antenna will give you a little sensitivity improvement.

Since most cases are not line of sight, the distance will be lessened depending on the amount and type of trees, foliage, hills, buildings, etc., in the path. On the other hand, there is temperature inversion ducting, especially in the summer months, or knife edge refraction that can equal or better the chart estimates. The RF horizon is about 10 miles for an antenna height of 50 ft - Miles = 2x sq.root antenna height in feet. If the other station also has an antenna height of 50 ft then you should get good results over the 20 mile path in flat terrain. Antenna height is most important at UHF (see The ARRL Antenna Book pages 1-4) Other sources of ATV information can be found in the 94-98 ARRL Handbook chapter 12.

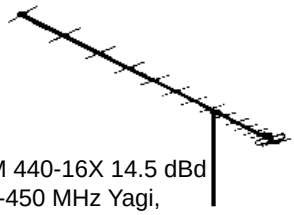
ANTENNA POLARIZATION must be the same in any area or you could be losing up to 20 dB by being opposite. Polarization in any area seems to be more of an emotional rather than technical decision. If most of the ATVers come from the weak signal or 432 SSB/DX group or using 439.25, they will push for horizontal. The FMers or those using 434.0 will push for vertical. The main motivation is not to have to get separate antennas for each mode of interest. Technically there is little difference between polarization's above 300 MHz according to a US Army study. However, below 300 MHz horizontal is generally better. Vertical polarization is preferred in areas that have a repeater or want omni directional coverage for weather radar or other public service applications due to the fact that there are many manufacturers of high gain vertical omnidirectional antennas for base station as well as mobile. Horizontal omni gain takes many more elements for the same gain as vertical and few are made commercially. So this is a regional decision that should be made by the local ATV community. One alternative is for individual ATVers to use circular polarized antennas, which works great for all modes. There are many exaggerated claims for antenna gain and performance. When you select yours, it should have sufficient bandwidth, and go by the actual measured gains published from the various VHF/UHF Conference contests rather than advertisements and unsubstantiated articles.



KLM 440-6X 8.9 dBd 420-450 MHz Yagi Mounts horzontal or vertical. 28" boom ideal for portable & public service uses.

Diamond F718A,J or L 9dBd vertical omni, 15 ft.

Broad band exposed dipole vertical 6-9 dBd omni used at inband repeaters with duplexer.

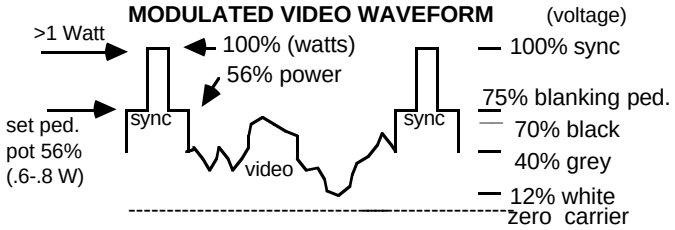


KLM 440-16X 14.5 dBd 420-450 MHz Yagi, 10.5 ft boom. FO-25 has 16 dBd and 17 ft boom.

REALIGNMENT OR TRANSMIT FREQ. CHANGE

A frequency not originally ordered with your TC70-1 can be changed to by plugging in the new crystal and peaking with a DC voltmeter. The crystals are video carrier freq. /4, 5th overtone, .005%, in a HC-25 holder. Push crystal all the way down into the socket, and then lift back up slightly so that the crystal can does not short out against the sockets. Refer to the board layout for emitter resistor test point locations.

Start at the oscillator and peak progressively toward the output. All peaking is done with no video connected and the 1K pedestal pot at maximum power (CCW). Use a small insulated tuning tool on the trimmer caps, and slowly rotate in the slot with very little downward pressure. The voltages shown are typical minimums. When you are done peaking all trimmers, reset the 1K pedestal pot to 75% of the value read at the output test point on the board, or 60% of the maximum power read on a power meter (Diamond SX-1000 2 Watt scale or Bird 400-2 slug). The blanking pedestal is now clamped to the proper level regardless of the applied video



The sound subcarrier frequency is set to 4500 kHz +/- 2 kHz by the 18µH variable inductor with a counter at the 330 Ohm resistor test point. Do not try to reset by listening to a TV set as it will give a false peak, be off in another TV, or give a crosshatch beat in color video if off frequency or injection level set too high. The amount of injection is set by the 500 Ohm pot to 15 dB down from the sync tip (-15 dBc) by us with a spectrum analyzer. Deviation is set at the 25 kHz broadcast standard by the op amp soft limiter. Readjust the frequency after setting the deviation.

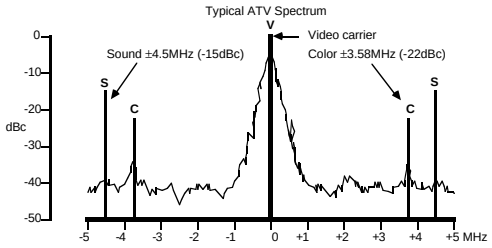
LINEAR AMPLIFIER SETUP

The pedestal must be reset to compensate for the differences between transmitters, amplifier gain curves, power saturation points, and applied DC voltage. The 1K blanking pedestal pot is used to reset to the proper video to sync level and should be adjusted whenever the amplifier is first put in line or the applied DC voltage is changed by more than .5 Volt , such as in going from base to mobile. If you are running the TC70-1 without an amp from a regulated 13.8 Vdc supply you need not touch this internal control. This control sets the video to sync ratio by clamping the blanking power level at the set value and stretching the sync tip to maximum regardless of the video gain control or average picture contrast.

To readjust for a different supply voltage, disconnect any video input and connect a DC voltmeter to the 5K monitor pot RF out test point on the board. You can also use a Diamond SX-1000 RF power meter, 2 Watt scale, in the antenna line. The RF output must be connected to a good low VSWR antenna or dummy load with no more than .1 Watt reflected. Turn on the transmitter and turn the 1K (PED) pedestal pot ccw - max reading - and then slowly reduce to 75% of that voltage maximum value. If a Diamond SX-1000 or Bird RF power meter is used, set to 60% of the maximum value. When the video source is plugged back in, the test point voltage or RF Watt meter readings will have no relevant meaning. If you have a scope, you can look at the video to sync ratio at the monitor output jack and it should roughly correspond in transmit as it does to the input camera waveform.

An external linear amplifier is set up the same way but a RF power meter must be used at the amplifier output. Use a good quality 50 Ohm interconnecting coax, short as practical, with N connectors. Use no adapters or elbows as the are very lossy at 70 CM. Again with no video plugged in, set the 1K pedestal pot for maximum indicated RF out of the amp, and then back down to 60% of what ever the maximum reading is. For example; ped. pot at max CCW the Mirage D26N normally reads 50 to 60 W (13.8 Vdc & Diamond SX-1000 200 Watt scale or Bird 100E slug). If 55 watts, turn the pedestal pot cw to 33 watts (55 x .6 = 33 watts).

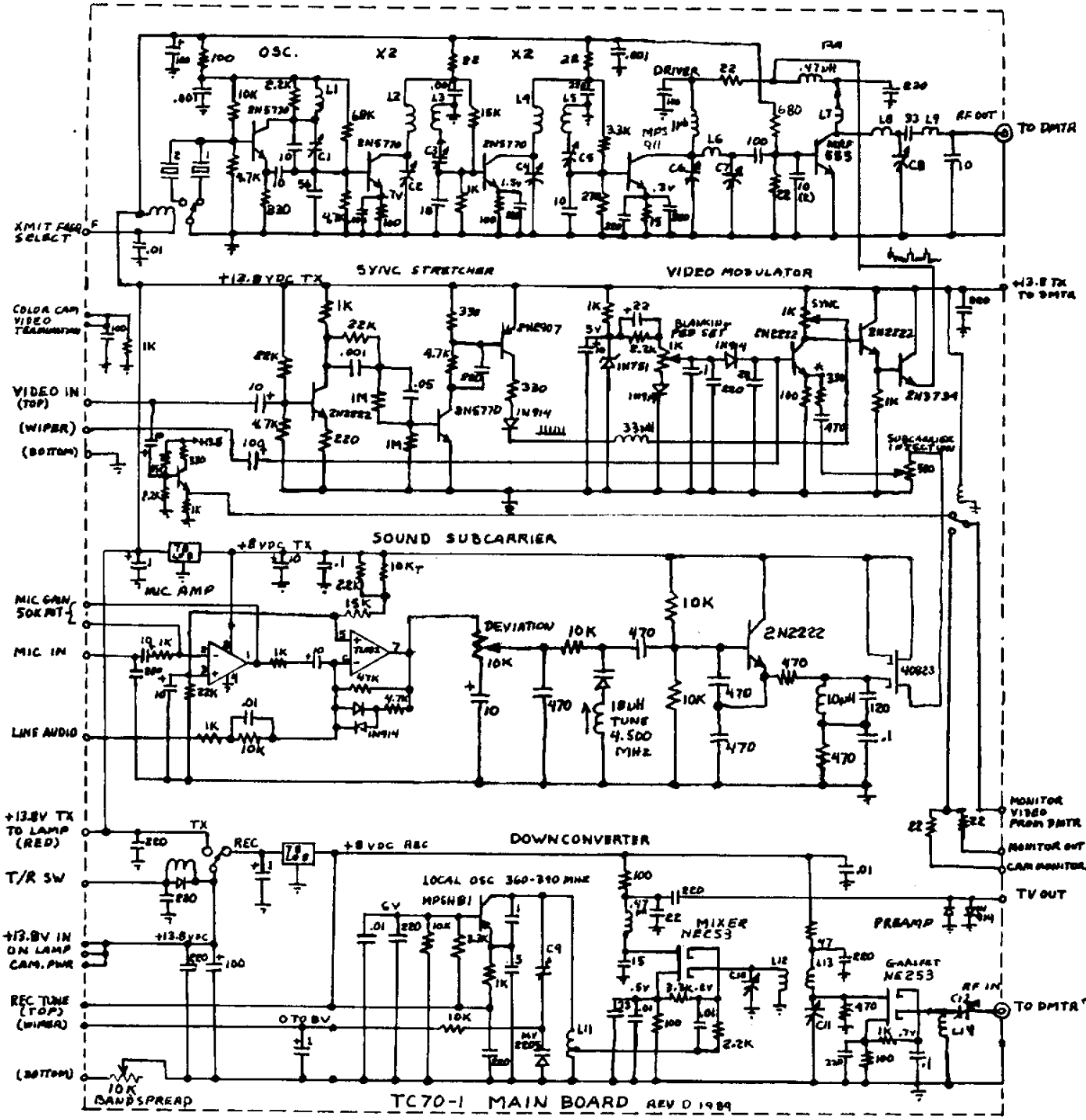
The sync tip power (peak envelope power) on all linear amps will still be the max power you read before the reduction to the blanking pedestal due to the sync stretcher in the modulator. Any further reading of an “average” reading RF Watt meter is meaningless as they do not respond normally to modulation above 100 kHz and the reading will vary depending on the picture contrast. An all white picture will give the lowest reading, and an all black one will read about the same as the blanking set up.

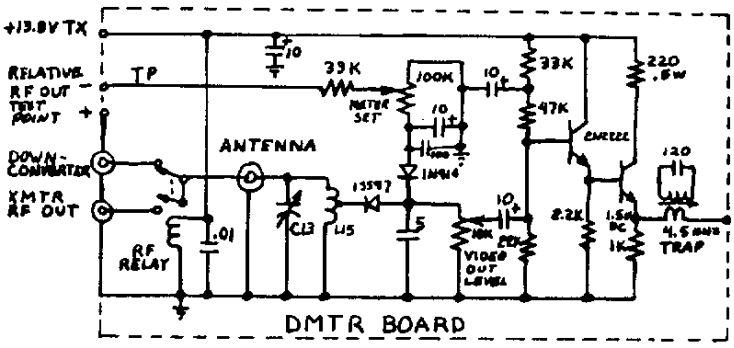


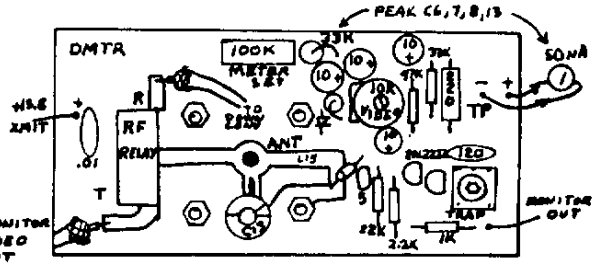
The spectrum above is normal AM double sideband. If your transmissions interfere with other band users near your lower sideband sound or color subcarriers, you may need a VSB filter in your antenna line. Vestigial sideband filtering should not be confused with SSB, it’s completely different. With VSB, nothing is done to the carrier and less than 5% of the sideband power is cut off. VSB only rolls off the lower sideband starting at .75 MHz below the video carrier frequency. FCC defines VSB as having the lower color and sound sidebands down more than 60 dB below the peak power (see spectrum above and also fig. 6 on pg. 20-3 in the 1987 and later ARRL Handbooks). The only way to achieve this with amateur “linear” amplifiers is to put a VSB filter in the antenna line. VSB filtering is not necessary at the transmitter except in the case of a repeater near the band edge below 424.6 MHz, in the presence of other transmitters with the possibility of creating transmitter intermod, or if there are other mode users near you that receive interference from your LSB subcarriers.

70 CM ATV FREQUENCIES and antenna polarities vary in different parts of the country. ATV repeaters and Frequency Coordination Councils are listed in the ARRL Repeater Directory. There are only 2 ATV channels available in the 70 CM band without the possibility of interference. Broadcast TV skips adjacent channels in a given area to avoid interference. The separation there is 12 MHz. If there is an inband repeater, then simplex is sometimes run on the repeater input, or another frequency with the possible interference accepted. Some areas have gone to crossband repeat with the output on either the 33 CM (923.25) or 23 CM (1253.25) bands which frees up one of the two 70cm frequencies for simplex, and the other for repeater input. Also the simplex frequency can be used for full duplex operation with another station on 910.25 or 1289.25 MHz. Crossband repeat or duplex allows receiving your own video back with just the addition of another antenna and downconverter.

The primary 70cm frequencies are 439.25 and 434.0 +/-22 kHz depending on the level of FM repeater activity in the 440-450 MHz segment, or Oscar satellite operation in the 435-438 MHz segment. With a video carrier on 439.25, you can give interference to FM stations on your color and sound subcarrier frequencies around 442.83 and 443.75, and receive interference in the picture from those transmitting below 444 MHz. With 434.0, your sideband energy will be about 40 dB down at 435 MHz which will only interfere with satellite stations very close to you, but their transmissions will tear up your received video. Most popular secondary simplex frequency is 426.25. It’s usually clear in most areas and shared with point to point links between 420-431 MHz.







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TC70-1 Schematic

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