CTA Cue Transmitter

Section

About Comrex

Comrex has been building reliable, high quality broadcast equipment since 1961. Our products are used daily in every part of the world by networks, stations and program producers.

Every product we manufacture has been carefully designed to function flawlessly, under the harshest conditions, over many years of use. Each unit we ship has been individually and thoroughly tested. Most items are available off-the-shelf, either directly from Comrex or from our stocking dealers.

Comrex stands behind its products. We promise that if you call us for technical assistance, you will talk directly with someone who knows about the equipment and will do everything possible to help you.

Our toll free number in North America is 800-237-1776. Product information along with engineering notes and user reports are available on our website at http://www.comrex.com. Our E-Mail address is info@comrex.com.

Warranty and Disclaimer

All equipment manufactured by Comrex Corporation is warranted by Comrex against defects in material and workmanship for one year from the date of original purchase, as verified by the return of the Warranty Registration Card. During the warranty period, we will repair or, at our option, replace at no charge a product that proves to be defective, provided you obtain return authorization from Comrex and return the product, shipping prepaid, to Comrex Corporation, 19 Pine Road, Devens, MA 01434 USA. For return authorization, contact Comrex at 978-784-1776 or fax 978-784-1717.

This Warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification performed by anyone other than Comrex Corporation.

With the exception of the warranties set forth above, Comrex Corporation makes no other warranties, expressed or implied or statutory, including but not limited to warranties of merchantability and fitness for a particular purpose, which are hereby expressly disclaimed. In no event shall Comrex Corporation have any liability for indirect, consequential or punitive damages resulting from the use of this product.

SECTION 1. INTRODUCTION

CUE SYSTEM

The Comrex Cue System relays program and instructions from a transmitter (installed in a van, studio, press box, stadium, etc.) to pocket receivers. It is built for ENG/SNG field control and configured specifically to provide maximum field operating range with broadcast-quality audio.

This system consists of the CTA Transmitter and LPQRA Receiver. The 1 watt CTA Transmitter accepts two audio inputs (program and cue) and combines these sources so that the cues automatically override the program, with program remaining audible at a lower level. The CTA is intended to be used with one or more LPQRA Receivers.

FCC REQUIREMENTS

The FCC permits holders of AM-FM or TV licenses to operate cue systems in the frequency bands of 26.1-26.48 MHz, 450-451 MHz and 947-952 MHz. The Comrex Cue System is only available in the frequency range of 26.1-26.48 MHz. A license must be obtained to operate this system. An application for authorization (FCC Form 601 & 601H) is available from the FCC's website www.fcc.gov/formpage.html or by calling the FCC's Forms Distribution Center at 800-418-FORM (3676). The rules governing this service are contained in FCC Rules, Part 74.

WHAT COMES WITH THE CTA?

The following items are shipped with a CTA:

(1) AC power cord
(1) Operating manual
(1) Warranty card (Please fill out and return.)

SPECIFICATIONS

Frequency Range: 26.1-26.48 MHz

Power Output: 1 watt

Connectors:
- *Antenna:* UHF Style (SO-239)
- *Cue & Program:* 3-pin XLR

Input Levels: -10 dBm (150 ohms) balanced

Power: 120 VAC 60/50 Hz (240 VAC optional)

Drain: 30 watts max

Size: 19" W x 5" D x 1.75" H

Antenna: External 50 ohm (not provided)

Section 2. Setup

The CTA Transmitter is typically installed in the “equipment” area (van, studio, press box, stadium, etc.). A 50 ohm coaxial cable should be run to the location of the transmitting antenna. The antenna should provide an impedance reasonably close to 50 ohms. A “citizens band” antenna (there are many types) manufactured for use at 27 MHz is adequate.

Simply connect the CTA to the audio source and antenna. Then, begin operating. “Peaking up to the antenna” is not necessary and is, in fact, an exercise in futility in most instances.

Audio signals from the program source are fed into the Program Audio Input via a 3-pin XLR connector. Audio signals from a two-way radio or other cueing source are fed into the Cue Audio Input by a 3-pin XLR connector. Both program and cueing audio levels should be checked to insure proper operation of the program ducking feature. To do this, listen to an LPQRA Receiver and confirm that the program level is adequate and is reduced when cues are sent.

With all high frequency systems, best operation in terms of distance, is obtained with the antenna of either the receiver or the transmitter elevated. Building walls attenuate 26 MHz signals sufficiently to warrant locating the transmit antenna inside the building for indoor use. Due to the high occurrence of broad or wide dead spots at this frequency, Comrex does not recommend using the CTA inside.

Section 3. Technical Details

The CTA Transmitter consists of two basic circuit sections — Audio and RF and the CTA is designed for 100% duty cycle.

RF Circuits

The RF portion is crystal controlled, frequency modulated and produces an output of 1 watt into 50 ohms. Referring to the schematic diagram at the end of this manual, Q1 is operated as a grounded base oscillator. The output resonant circuit in the collector of Q1 is coupled to the doubler and to its own emitter by means of a capacitance tap. The frequency determining crystal is operated at its series resonant frequency and is located in series with the feedback to the emitter. CR1, a voltage variable capacitor, is also in series. A DC bias is summed with the output of the audio portion of the CTA and applied through R7 to CR1. As the audio varies, so does the capacitance of CR1 and the oscillator frequency. The electrical characteristics of the crystal constrain the oscillator to remain within very narrow limits.

Transistor Q2 is utilized as a temperature compensation diode for the voltage variable capacitor diode CR1. Q2's voltage drop changes because of temperature changes in CR1 due to the same temperature variances.

The output of the oscillator is at one half of the transmitter output frequency. The crystal frequency is, therefore, one half of the carrier frequency. The crystal is of the fundamental type and is operated at its series resonant frequency. To order a replacement crystal, ask for a "Fundamental Series Resonant" crystal in an HC-25 case, cut to a frequency which is one half the operating frequency. This crystal is available from Sentry Manufacturing, at 405-224-6780, part number 1669 (specify desired frequency).

The output of the crystal oscillator is raised to the carrier or operating frequency in the frequency doubler stage Q3. This stage is optimized for operation as a doubler. Its output is filtered by a double tuned filter made up of L2, L3, C15, C16 and C20. When the output of the oscillator goes through a positive excursion, so does the base of Q3. When the base voltage reaches approximately 0.6 Volts, the transistor turns on and a current pulse flows in the collector/emitter circuit. Because this pulse occurs for less than 360 degrees, the output is rich in harmonics. If the angle of flow is properly chosen, the second harmonic output will be optimized and the stage will be an efficient doubler. Because no current flows in the emitter except when the input from the oscillator is sufficient to turn on the transistor, the voltage across the emitter resistor will, if integrated, provide an accurate indication of the drive level. This is an indication of whether the oscillator is operating as well as an indication of its output. TEST POINT 1 is monitored with a voltmeter during tune-up to ascertain the operating condition of the oscillator circuit. See the “Maintenance” section on pages 9-11 for more information on tuning. The output of the doubler circuit is fed to Q4 which is a pre-driver. It is configured as an emitter follower. A diode rectifier in the emitter circuit of Q4 is used to measure its output. The DC voltage measured at TEST POINT 2 is an indication of the operation of the oscillator and the doubler and the alignment of L1, L2 and L3.

The output of the Q4 emitter is fed to the gate of the VMOS FET Q5 which is the driver for the output stage. It is operated as a source follower. It is coupled to the gate of the output VMOS FET Q6 by the matching circuit which is composed of L4 and L5. Although L4 and L5 are variable inductors, their tuning is so broad that they should not be considered as adjustable components.

The FINAL or POWER AMPLIFIER Q6 is matched to the load (which is a nominal 50 +j0) by means of the matching filter which is composed of L6, L7, L8, C30, C31, C32, C33 and C34. This filter was computer designed. It is very effective both as a matching network and as a filter. It is different from the simple filters found in older designs. L9, L10, L11 and C68 form a M-Derived low-pass filter tuned to reduce the level of the harmonic output of the transmitter.

Power to operate the CTA is obtained from the AC power lines or “mains.” Power transformer T3 converts the input 115V 50/60 Hz (strappable to 230V) to 24V Ct. The output of the transformer is full wave rectified by CR13 and CR14. C61 is the filter capacitor for the rectifier. The DC voltage from the rectifier filter system feeds the voltage regulator, U5, which regulates the voltage at 12V DC (the supply voltage for the various circuits of the CTA). Another voltage regulator, U1, is used to supply a regulated lower voltage to the oscillator.

Audio Circuits

The audio portion of the CTA Transmitter is configured to perform several important functions:

- Amplifies the input signal to a level sufficient to modulate the oscillator.
- Pre-emphasizes the audio to complement the de-emphasis that is included in the receivers (200 microseconds).
- Filters out unnecessary audio components.
- Adjusts the gain of the system to prevent over-modulation, regardless of the input levels.
- Provides the function of “ducking limiting.” This function is described on the following page.

U2A is an operational amplifier configured in the summing mode. U2B is operated as a unity gain buffer between the pre-emphasis networks and the low pass filter. U3B and its associated circuitry is a low pass active filter of third order 1/2 db Chebyshev type response. Its function is to pre-filter the signal fed to the AGC system which follows.

The compressor/limiter consists of U3A, U4A, U4B, gain controller Q7 (which is a FET) and the rectification charge-discharge circuitry. An incoming signal, which if left unlimited would over-modulate the transmitter, is detected by the peak limiter that has an attack time of 225 microseconds. A DC voltage is then fed to the gain controlling FET, causing it to reduce its source-drain resistance. The input level to U3A is controlled by the voltage divider network formed by R51 and the source-drain resistance of Q7. Therefore, as Q7 decreases in resistance, the input voltage to U3A is reduced, the gain is designed to operate on overdrives of short durations, and the compressor time constants are arranged to adjust the gain to prevent over-modulation by inputs, which are more or less continuous in nature. The attack and recovery times of the compressor are much longer than those of the peak limiter. The compressed and/or limited output of U4A is fed to the voltage variable capacitor which modulates the oscillator. A modulation adjustment control, R47, is provided to permit precise adjustment of 100% modulation level.

DUCKING LIMITER

The CTA Transmitter limiter is arranged as a “ducking limiter” with two inputs. If the input sensitivity of one channel is greater than the other and both inputs are the same level, an input from the higher gain channel will cause the limiter to reduce the amplification that it provides to both channels, and the lower gain channel will seem to have been “turned down.”

The CTA Transmitter feeds program and instructions to operating personnel and talent who will be moving about. Most of the time, the program in progress will be fed into the PROGRAM INPUT and be heard in the cue receivers. At various times, the directors give instructions to the talent or crew. If these instructions were simply mixed with program and fed into the CTA, both would be heard at the same level, and the instructions could be missed. The solution to this problem is to remove program while the instructions are being given. Without complicated remote control equipment, the removal of program during instructions is difficult because in a remote van the program is received on an off air monitor and instructions are fed to the van by means of a two-way radio or a sub-carrier on the aural carrier.

The ducking limiter is ideal for this function. The program is fed into the program input and the instructions from the two-way radio or sub-carrier receiver are fed into the cue input. When no instructions are being sent to the van, the program is transmitted to the field personnel. When an instruction does come in, it goes into the cue input and causes the program to be suppressed while instructions are being sent. Thus, instructions (cue) take priority over program and the likelihood that they will be missed is eliminated.

SECTION 4. MAINTENANCE

The CTA Transmitter is designed and manufactured under rigid controls, so that it will provide long, trouble-free service. Except for failure of a mechanical component due to normal wear and tear, little, if any, repair should ever be required. All components are operated well below their maximum ratings. The oscillator is crystal controlled by an ultra stable crystal. The resistors are the best available, and the capacitors are all temperature compensating or temperature stable. The circuits used in the CTA are designed to operate under most conditions encountered in the field. In particular, they were chosen because they would require little or no touching up or "tweaking" for extremely long periods of time, if cared for properly. We, therefore, recommend that retuning be attempted only if performance of the system has deteriorated markedly.

TUNING EQUIPMENT REQUIRED

The following equipment is required to tune the CTA:

- Analog Voltmeter — a digital voltmeter may be used, but it will be difficult to determine maxima during adjustments.
- Power Meter — Bird Model 43 with 80M coaxial load and 5 watt insert for the 26 MHz range. Avoid using "CB" type wattmeters.
- Modulation Monitor — this monitor will require a 200us de-emphasis network. Do not attempt to read or set modulation of the CTA with a "two-way radio" modulation monitor. If your monitor does not have a 200us de-emphasis network, perhaps you should consult with the manufacturer about ways of adding one. The "two-way radio" pre-emphasis/de-emphasis networks are at 750us. Attempting to use a modulation monitor with a 750us de-emphasis network in order to measure a transmitter with a 200us pre-emphasis, will result in large errors.
- Spectrum Analyzer — this is not absolutely necessary, but if you have one available, it is a good idea to use it. Measurements made on a communications grade spectrum analyzer may be erroneous due to front end overloading. Comrex employs a Tektronix Model 7L13 in our factory tune up procedures. Check the transmitter with a similar quality analyzer before attributing harmonics or spurious noise to the CTA.
- Audio Oscillator — this oscillator should be able to provide outputs at levels up to 1 volt into 600 ohms.
- Frequency Counter — this should be an RF counter with a stable time base that includes a TCXO or OCXO oscillator. It should also be capable of measuring a minimum of 50 to 60 MHz.

TUNING STEPS

Step 1 — Tuning the oscillator: Connect the voltmeter to TEST POINT 1. Set the VM range so that 0.2V DC will be easily read. Using a nonmetallic tuning tool, adjust the core of L1 until it is about 60% out of the coil. Do not start with the core in any further. The oscillator will not be oscillating at this point, and there will be no indication on the voltmeter. Slowly turn the core clockwise with the nonmetallic tuning tool. At some point you will begin to see an indication on the voltmeter. Continue to turn the core in, and the voltage will begin to drop. Keep turning until the oscillator quits. Next, back the core out to the starting point (about 60% out of the coil). The purpose of this exercise was to acquaint you with the way the oscillator tunes. Adjust the core again until the oscillation just starts. Turn it a tiny bit further until the indication on the voltmeter increases slightly. The oscillator is now tuned. The voltage should be approximately 0.2V DC at TEST POINT 1 (this will vary slightly from unit to unit).

Step 2 — Tuning the double tuned filter: Change the voltmeter range to a range capable of reading 3V DC. Move the voltmeter probe to TEST POINT 2, which is the output of the doubler. This portion of the tune up procedure will adjust L2 and L3. If step 1 was performed correctly, there should be a reading on the voltmeter. If there is no reading, review step 1. If there is still no reading after reviewing step 1, check all connections because it is not likely that a transistor has failed. Of course, L2 and L3 could be so far out of tune that nothing would get through, but no reading would be out of the ordinary. With a reading at TEST POINT 2, adjust L3 and then L2 for a maximum reading (make sure you do it in this order). The voltage should be approximately 3V DC.

Step 3 — Tuning the output: L4 and L5 are part of a broad band network and need no tuning. With a watt meter/load combination connected to the antenna connector, J3, you should be getting an indication of power output on the watt meter. Adjust L7, L8 and then L6 (in that order) for maximum power output. C68 is adjusted to attenuate the second harmonic. The only way to make this adjustment is with a spectrum analyzer. L6, L7, L8 and C68 adjustments interact, so you may have to re-tune them. At least 1 watt output should be present — if not, redo this procedure.

Step 4 — Setting the frequency: The trimmer capacitor C3 is used for setting the transmitter on frequency. Couple the output of the CTA to the frequency counter, and adjust C3 until the frequency indicated on the counter is the correct one. Make sure to use a nonmetallic screwdriver when making this adjustment. A metal screwdriver will cause the frequency to change when removed from the C3 slot.

Step 5 — Setting the modulation level: This procedure will set the gain of the modulator and the maximum modulation frequency deviation. This step should only be performed with a 200us de-emphasis modulation monitor. Two gain pots (R34 and R36) and the modulation pot (R47) are adjusted in this step. Turn all of these pots clockwise until you hear clicks. These are 25 turn pots (the clicks are the only indication that you have turned them all the way up). Next, couple the modulation monitor to the CTA, being careful not to overdrive the input of the modulation meter. Connect the audio oscillator to the Cue Input, and adjust the oscillator for 400 Hz at 0.25 RMS. Turn R47 until the deviation indicated on the modulation monitor is 5 kHz peak. Move the audio oscillator to the Program Input, and set R36 for 1.5 kHz peak deviation.

The CTA Transmitter is now tuned and ready for use. Please contact Comrex Customer Support if you have any questions concerning the operation or adjustment of the CTA.

SECTION 5. ENGINEERING NOTE

CTA & INTERFERENCE

Occasionally, a customer experiences interference problems when using a CTA Transmitter in a remote truck or van. Often the assumption is made that the transmitter is emitting harmonics with the other equipment in the van. The purpose of this note is to discuss the problems involved and suggest ways of solving them.

Each and every CTA is tested very carefully to make sure that it does what the specifications say it should do. The output is checked on a TEKTRONIX spectrum analyzer to make certain that harmonics are as low as possible. The final test specification calls for all harmonics to be at least 50 dB below the rated 1 watt output. This means less than 10 microwatts of harmonics. Usually, the harmonics are more than 55 to 60 dB below 1 watt, and they should remain that low permanently, unless attempts are made to “tweak up” the CTA without a spectrum analyzer.

Typical problems include interference with the van TV receiver or hum and/or buzz in audio circuits. The causes of these problems are different, and they are discussed separately below.

Hum and/or buzz in audio circuits are most often caused by the way the CTA is installed in the truck. The 1 watt of RF energy generated in the CTA must be conveyed from the output connector through a “leakproof” cable to the antenna. The antenna is not just the rod which sticks up above the truck; it is also the ground plane under it (in this case, the roof of the truck). You should think of the truck roof/antenna rod interface as a place which should be RF “tight,” so that no RF can leak back into the truck. If RF gets loose inside the truck and gets into the power cables of other equipment and meets the power rectifiers, it is modulated by 120 Hz and reradiates into the microphone input stages. It is this rectified RF that appears in the van audio circuits and produces the buzz and hum. If you wish to eliminate the hum and/or buzz in the audio, the RF in the truck must be eliminated.

If you have purchased a “CB” type antenna to use with the CTA and are using the co-ax cable that came with it, you will probably have to change the cable to double shielded co-ax. Also, if you have purchased one of the short center fed types, you may be experiencing very high VSWR. It is better to buy a “professional” antenna.

After changing to better cable, you will want to make sure that the CTA is truly grounded to the truck body, the equipment racks and anywhere else you can find. You may have to invest a bit of time in experimenting, but it will be worth it. The co-ax must be bonded to the roof of the truck where it goes through to the antenna. A poor ground here can negate all of your other efforts.

Note: Sometimes a customer is puzzled that the CTA Transmitter causes interference when another transmitter such as a remote pickup unit does not. This is because the remote pickup transmitter usually operates in the 160 MHz or 450 MHz frequency ranges, and the antenna's co-ax cables are of high quality. It you attempted to use a "hobbyist" type antenna on a 160 MHz or 450 MHz transmitter, most of the generated power would go to heating up the co-ax dielectric.

TV reception interference can also be a problem. Before going further we should point out that the front ends of most TV receivers are very broad band and often consist of just a mixer without much filtering. The most popular TV receiving antenna, it seems, is the round flat "frisbee" type. These units often use a bipolar transistor amplifier to raise the received signal level and to match the co-ax. They are very broad band. Any strong signal injected into the input of one of these units is likely to be rectified by the input amplifier. Rectification produces harmonics. If there are other strong signals at the rectifier junction, you will get harmonics and inter-modulations. If you feed these into a broadband TV receiver, interference is inevitable.

So, how do you get rid of this type of interference? First, make sure that all of the steps prescribed above for problems in audio circuits have been taken. It is important that no loose RF is circulating about within the van. Next, it will be necessary to remove the transistor at the antenna. You could just cut it out and connect the antenna elements directly to the co-ax. This will reduce the sensitivity, but you may have enough signal that the loss will not be noticeable. Finally, we manufacture a 26 MHz notch filter which can be inserted in the co-ax run. This may reduce the 26 MHz signal at the TV set input enough that the TV set mixer will not produce harmonics itself (this is assuming that you are using a very good TV receiver).

Note: Please remember that the CTA is not producing harmonics strong enough to interfere. The very strong 26 MHz is being multiplied either in your antenna or in your TV receiver.