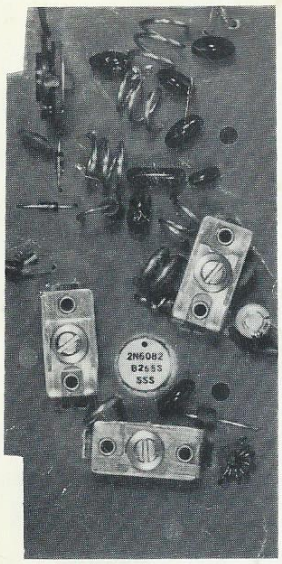
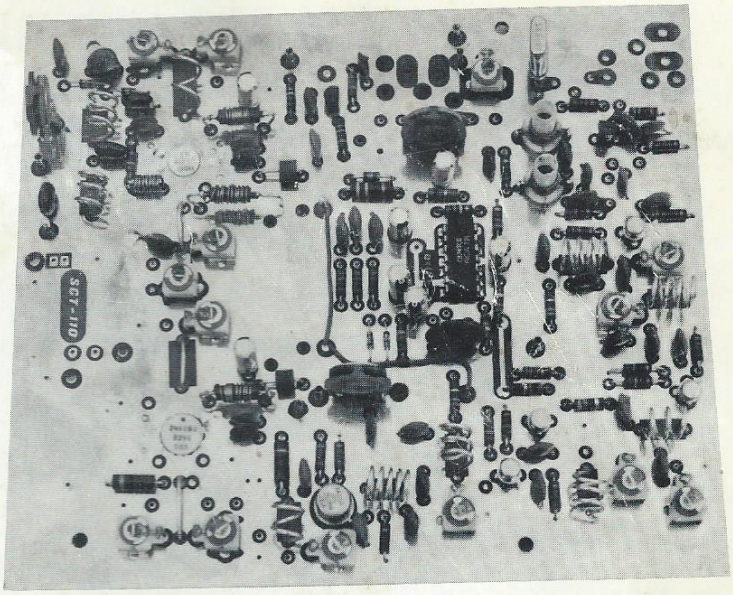
SCT 110
TRANSMITTER BOARD



BA-10 30WT.
AMP BOARD



SCT110

THE SCT110 TRANSMITTER BOARD IS A COMPLETELY SELF-CONTAINED 10 WATT VHF FM TRANSMITTER. THE DESIGN EMBODIES YEARS OF EXPERIENCE IN TRANSMITTER DESIGN AND WAS SPECIFICALLY DEVELOPED TO BE THE ULTIMATE IN REPEATER EXCITER UNITS. THE BOARD INCLUDES AUDIO AMPLIFIER/CLIPPER-FILTER, OSCILLATOR, FM MODULATOR, MULTIPLIER, DRIVER AND FINAL AMPLIFIER STAGES ALL ON ONE DOUBLE-SIDED G-10 MILITARY QUALITY BOARD, ALONG WITH DC SWITCHING, AND VOLTAGE REGULATOR CIRCUITRY. THE UNIT IS COMPLETELY SOLID STATE AND "STATE OF THE ART". IT HAS BEEN CAREFULLY DESIGNED TO BE EXTREMELY LOW IN BROADBAND "WHITE NOISE" AND OTHER SPURIOUS EMISSIONS. MULTIPLICATION OF THE CRYSTAL FREQUENCY IS KEPT TO A MINUMUM IN ORDER TO KEEP THESE EMISSIONS AS LOW AS POSSIBLE. THE ENTIRE TOP SIDE OF THE PC BOARD IS COPPER "GROUND PLANE" WHICH PROVIDES EXCELLENT GROUNDS FOR ALL OF THE VARIOUS STAGES AND A MEASURE OF SHIELDING FOR THE SIGNAL TRACES ON THE OTHER SIDE OF THE BOARD. THIS MAKES FOR THE ULTIMATE IN TRANSMITTER STABILITY AND OPTIMUM OVERALL PERFORMANCE EVEN OVER WIDE TEMPERATURE RANGES. THE FM MODULATOR HAS BEEN DESIGNED FOR LOWEST POSSIBLE MODULATION DISTORTION AND MAXIMUM FIDELITY. THE "ON THE AIR" SOUND OF THE TRANSMITTER IS **EXCELLENT** IN QUALITY. SO MUCH SO, THAT WITH A LOW DISTORTION RECEIVER, THE **RE-TRANSMITTED** AUDIO SOUNDS LIKE DIRECT COPY. PRE-EMPHASIS IS 6dB PER OCTAVE, PER EIA SPECS. THE TRANSMITTER IS SUPPLIED IN A SINGLE CHANNEL CONFIGURATION, BUT MAY BE MODIFIED FOR OPERATION ON UP TO 3 CRYSTAL CONTROLLED FREQUENCIES.

Also available in complete Shielded Housing Assembly - as used on the SCR1000 Repeater.

SPECTRUM COMMUNICATIONS
'Specialists in Repeater Systems'
1055 W. GERMANTOWN PIKE
NORRISTOWN, PA. 19401
C/O ~~215~~-631-1710
KEVIN SCHAEFER

SCT-110

SPECIFICATIONS

FREQUENCY RANGE	136-174MHz; 220-240 MHz
POWER OUTPUT	10 WATTS (MIN.) @ 13.5VDC. 7WT. 2M UNIT ALSO AVAILABLE - TO DRIVE BA-10 AMP. BOARD.
CURRENT DRAW	1.5 - 2.2A TYP. @+12-14 VDC.
MODULATION	"TRUE FM" FOR THE ULTIMATE IN AUDIO QUALITY. **LOW DISTORTION** MODULATOR WITH INSTANTANEOUS DEVIATION LIMITING (CLIPPING) AND MULTISECTION AUDIO LOW PASS FILTER, FOR MINIMUM FM SIDEBAND ENERGY AND BEST SOUND.
AUDIO INPUT IMPEDANCE	40K OHMS NOM.
DEVIATION	ADJUSTABLE UP TO ±7KHz. FACTORY SET TO ±6KHz MAX PEAK DEVIATION.
FINAL STAGE	**INFINITE VSWR PROTECTED**. NO SHUTDOWN REQUIRED.
SPURIOUS	−75dB TYP.
HARMONICS	−65dB MIN.
"WHITE NOISE"	−90dB MIN. @ ±600KHz
TEMPERATURE STABILITY	±0.001% NOM. FROM −10 TO +60°C.
CRYSTAL INFORMATION (136-174MHz)	CRYSTAL $F_o = \frac{\text{TRANSMIT FREQ.}}{8}$
(220-225MHz)	CRYSTAL $F_o = \frac{\text{TRANSMIT FREQ.}}{12}$
	FUNDAMENTAL MODE, PARALLEL RESONANT, 32pF LOAD CAPACITY. 25 OHMS OR LESS AT RESONANCE. HC-25/U CASE. TOLERANCE: ±0.0005% (−10 TO +60°C.)
CRYSTAL	ONE±0.0005% HIGH STABILITY COMMERCIAL GRADE CRYSTAL SUPPLIED.
SIZE	5 ⅝" X 6 ⅜"

BA-10 (136-174MHz) & BA-10A (220-240MHz) 30 Wt. AMPLIFIER BOARDS

POWER OUTPUT	30 WATTS TYP. (25Wt. MIN. 136-174MHz.) AT +13.8 VDC.
RF DRIVE REQUIREMENTS	7Wt. NOM. @ 136-174MHz. 10-12Wt. NOM. @ 220-240MHz.
DC CURRENT DRAW	3.5A NOM. @ 13.8 VDC.
HARMONICS	−60dB MIN.
HIGH VSWR	AMP. TRANSISTOR IS THE BALASTED EMITTER TYPE AND WILL WITHSTAND INFINITE VSWR FOR UP TO 1 MIN. NO SHUTDOWN REQUIRED.
SIZE	2 X 4"

Specify BA-10 OR BA-10A, AND FREQUENCY.

MOUNTING AND HEAT SINKING

MOUNT THE BOARD WITH THE FOUR STANDOFFS PROVIDED. THE STUD TRANSISTOR(S) MUST BE BOLTED TO A HEAT SINK WHICH IS CAPABLE OF DISSIPATING SEVERAL WATTS. (NORMALLY THE SHIELDED ENCLOSURE IS SUFFICIENT.) BE SURE TO USE A SMALL AMOUNT OF THERMAL GREASE ON THE TRANSISTOR'(S) FLANGE FOR GOOD HEAT CONDUCTIVITY. TIGHTEN THE NUT(S) ON THE STUD(S) ONLY SNUGLY. **DO NOT OVERTORQUE** - AS THE STUD COULD BREAK-OFF!

FOR REPEATER APPLICATION, THE BOARD MUST BE MOUNTED IN A TIGHTLY SHIELDED BOX. (SPECTRUM COMMUNICATIONS CUSTOM HOUSING OR BARRY ELECTRONICS #46R-106A RECOMMENDED). FEED THROUGH CAPACITORS (APX 1000pF) MUST BE USED FOR **ALL** DC AND AUDIO LINES ENTERING THE BOX (EXCEPT GROUND). A UHF OR TYPE N CONNECTOR IS RECOMMENDED FOR RF OUTPUT.

SCT - 110 TRANSMITTER

1.0 Tune-up

Each board is carefully adjusted at the factory for minimum spurious and maximum power output. In some cases however, it may be necessary to "tweak" the output network for optimum performance with the exact antenna or power amplifier in use. The two trimmer capacitors, C252 and C253, near the final amplifier Q209 may be adjusted for this purpose. In most applications, the trimmers will be carefully adjusted for maximum output power consistent with minimum current. In some applications, however, it might be necessary to reduce the power output slightly. The best way to achieve small power reductions is to adjust the C252 and C253. Turn these trimmers in the direction which produces the maximum drop in current consumption consistent with the desired power output. Power output can also be adjusted down to about 6 watts by adding a 5-10 wt.W.W. resistor in series with Q207's collector B+ lead as shown on the schematic. (Appx. 45 ohms typ.) Pads are provided on PC board for this. Note: Applies to 10wt. boards only. See Note ①.

2.0 Interconnections - See Figure 7.

2.1 DC Input: Terminal E205 is the main 13.5VDC Input.

2.2 PTT - This terminal is used to "key" the transmitter by connecting it to ground. Whatever device is used to switch this terminal should be able to "sink" up to 25mA. The terminal voltage must be allowed to rise to the full supply voltage to turn the transmitter off. (A small switching transistor such as 2N2222 may be used to switch this point, or a relay, etc.).

2.3 RF Output - E208 at rear of board. (Solder coax shield to P.C. board ground.)

2.4 AF Input - High Impedance, > 30K ohm. (Additional A.F. Inputs may be coupled - in through 20K ohm (or greater) resistors in parallel with the main A.F. Input.

2.5 Sub-Audible Tone Input - For "PL" sub-audible tones only! (Less than 200Hz). Terminal E202.

2.6 Ground - Solder a ground wire to the top (ground-plane) side of the P.C. board.

2.7 Relative Output - to 1mA DC Meter. Terminal E207. (Optional)

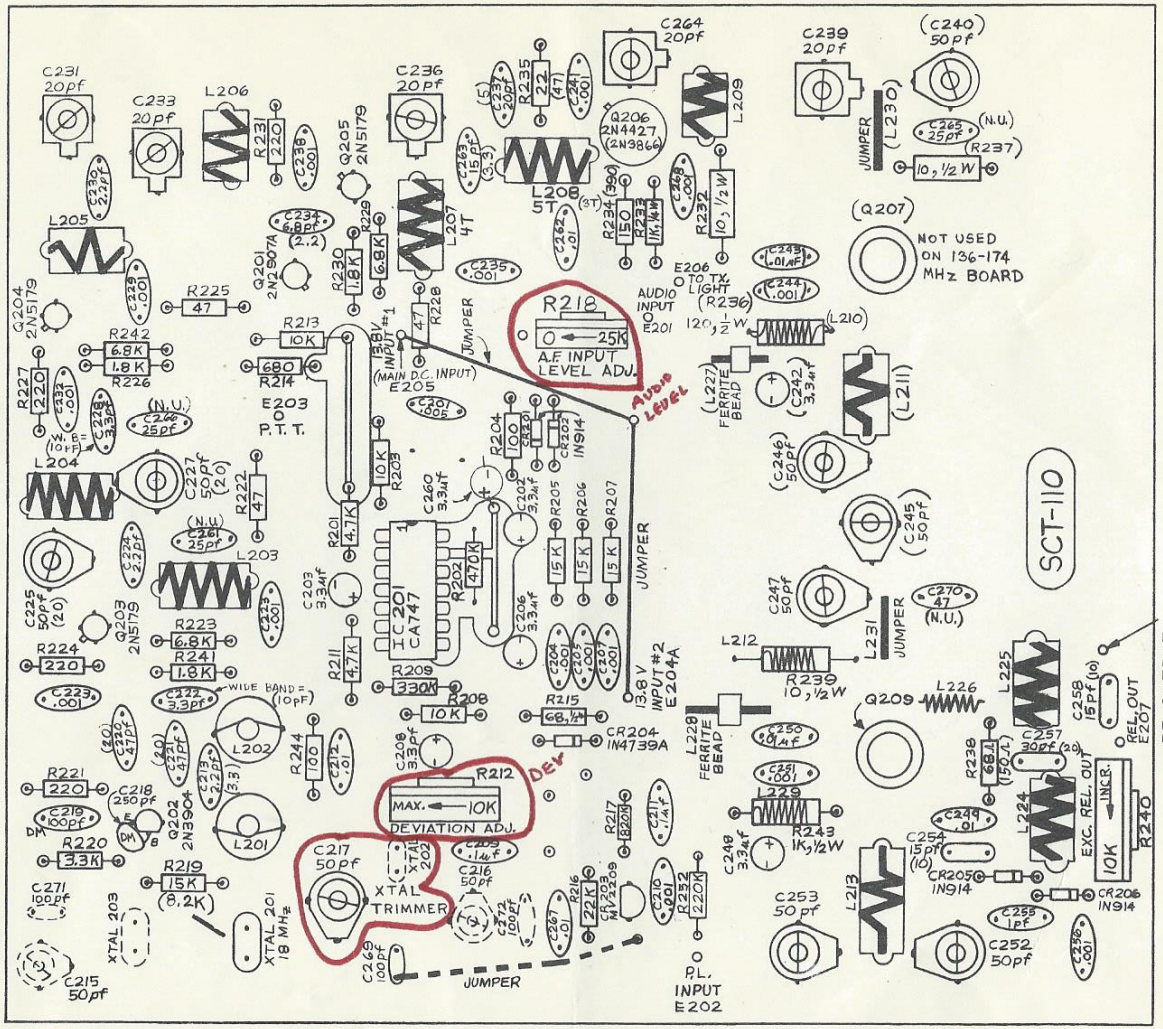
3.0 Modulation

Audio input to this board should be adjusted by means of R218 the AF Input Level Adjust Pot. The function of this pot is similar to that of the "mic gain" control found on many

transceivers in that it adjusts the amount of audio "clipping" of the transmitted signal. The deviation control on the board sets the absolute max peak deviation and is normally factory set for 6KHz max. (This prevents overdeviation of the transmitter regardless of the audio input level.) For Repeater service, the audio input level control should be adjusted so that a signal into the repeater receiver (deviated 5KHz) deviates the repeater transmitter to just 5KHz also. This will keep the transmitter audio stages out of clipping and will result in lowest possible system distortion. In this manner, only overdeviated received signals will drive the transmitter into clipping - thus preventing overdeviation of the repeater transmitter. Remember - all signals coming into the repeater are already speech processed. Any further processing (clipping) only results in needless distortion.

If desired, the audio response (pre-emphasis) of this board may be "custom tailored" by changing the value of C201,(0.005uF normally). For more "lows" (bassy sound), increase the value ofC201. The smaller the capacitor value, the less "lows" and more "highs". Normally, this should not be required, as the pre-emphasis is near perfect. (6db/ octave.) Typical AF Input level for 5KHz deviation is 100mV p-p for a 1KHz tone.

Note ①. On 2M unit - if the SCT110 is used to drive the BA10 Amp., a 7 Wt. version of the SCT110 is used. (Q207 driver stage is not used.)



NOTES:

1) VALUES IN ( ) ARE FOR 220 MHz UNIT. (N.U.) = NOT USED ON 220 MHz UNIT.
2) NOT ALL PARTS SHOWN ARE USED ON ALL VERSIONS OF THE SCT-110.

SCT-110 TRANSMITTER BD.
COMPONENT LAYOUT

SCALE: 2:1	APPROVED BY: J.D.C.	DRAWN BY R.L.A.
DATE: 11-14-77		REVISED 2/20/80

FIGURE 7

DRAWING NUMBER 3200

4.0 THEORY OF OPERATION

Initial FM signal generation is accomplished at Q202 and its supporting circuitry. This stage is a modified Clapp oscillator with the 18MHz crystal operating on the inductive slope of its parallel resonance curve. The collector circuit of Q202 is resonated at the second harmonic of the crystal frequency, (third harmonic on 220MHz versions), by a double-tuned filter, and is applied to the base of Q203, a frequency doubler. FM modulation is affected by "modulating" the crystal load capacitance with varactor diode CR203. A steady-state D.C. bias for CR203 is provided by R218, and the modulating audio signal is superimposed on this voltage through C209.

Modulating audio for CR203 is pre-emphasized by R203, C201 and C259, and is applied to IC201A where it is amplified by a factor of 68. The output of IC201A is applied to "back-to-back" diodes CR201 and CR202 which cause the audio signal to be limited to a maximum value of about 1.4Vpp. The limited audio signal is next applied to a 3 section RC lowpass filter which removes most of the high order harmonic distortion produced by the limiting process. The output of the lowpass filter is fed to IC201B for further amplification, and is finally connected to the varactor modulator through Deviation Pot R212.

The RF drive to Q203, now at 36MHz (55MHz in 220MHz versions), is doubled in frequency and is filtered by another double tuned circuit before being applied to the base of Q204. Q204 is another frequency doubler, and the 72MHz drive at its base (110MHz in 220MHz versions), is multiplied in the collector circuit to 144MHz (220MHz), the final output frequency. The signal is again filtered in a double-tuned circuit, and is fed to the base of pre-driver Q205. The signal is further amplified by Q206, and is applied as drive to the Class "C" amplifier chain consisting of Q207 and Q208. (In SCR1000 2M repeater applications, the output from Q206 is applied directly to Q208, and Q207 is eliminated. Power output from Q208 in this case is about 6-7 watts.) The output of Q208 (about 10-12 watts in 220MHz versions) is finally applied to a 2 section harmonic filter, and is routed to the RF output of the board. A sample of the RF output from Q208 is picked off before the harmonic filter, and is rectified by CR205 and CR206 to drive a Relative Output meter.

The 13.8VDC input is applied directly to Class "C" stages Q207 and Q208, and also to audio stage IC201. Oscillator stage Q202 is run continuously from a 9 volt zener diode regulator for maximum stability. Grounding the PTT input to Q201 causes Q201 to turn on, applying +13.5 volts to both frequency doubler stages and both pre-driver stages.

The RF output of exciter board is next applied to the final amplifier board. The final amplifier is Q208 (or Q209), an emitter ballasted RF power transistor. The power amplifier is designed with sufficient heat-sinking to provide a nominal output of 30 watts in continuous service when operated into a proper 50 ohm load. The power transistor is capable of withstanding open and shorted load conditions for short periods of time, but this should be avoided, since certain VSWR conditions can cause excessive heat buildup in the amplifier and possibly damage the device.

The output of the amplifier is passed through a 3 section (2 section on 220MHz) lowpass filter which greatly attenuates all harmonics. A diode rectifier provides a relative indication of peak output voltage which is sampled just ahead of the lowpass filter. R247 is set for a relative final output reading of 6-8 on the meter for approximately 30 watts out to a 50 ohm load.

5.0 Alignment. If alignment is necessary, perform only the applicable steps below.

5.1 Observe the Exciter Current Meter, with no crystal installed, the unit should draw 125-200mA in the transmit mode.

Check operation of the audio processing stages by connecting an oscilloscope probe to the wiper of the deviation control. With an input at E201 from an external audio generator, the waveform should be a clean sine-wave, turning into square wave as the input audio level is increased. Adjustment of the deviation control should produce up to 7 or 8 volts of peak to peak audio at this point. When proper operation of these stages has been confirmed, set the deviation control at its mid-point and check for the modulated signal on a nearby receiver or deviation meter.

Install the crystal in its socket and key the transmitter. The indicated exciter current consumption should be noticeably higher, (about 1.2 Amp. @ 6W out, and about 1.6-2.2 Amp. @ 10W out for the 220MHz board.) A VHF RF power meter connected to the antenna connector should now indicate some RF output. Tune all trimmer capacitors for maximum RF output. C277 and C278 in the input circuit of the 30W power amp. stage are adjusted for maximum drive to the device (indicated by final collector current), while C282 is adjusted for maximum power output consistent with good efficiency, (minimum collector current. Normally, CW adjustment). When tuning this stage, observe that tuning the output trimmers in one direction, (normally CCW), will cause a sharp rise in collector current with only a small change in output power. This indicates a decline in stage efficiency and should be avoided. When operating properly, the stage should draw 2.7 to 3.5 amps (at 13.8V) for 30W output, and, in no case should the stage collector current be allowed to exceed 3.5 amps. Always tune the amplifier for maximum output efficiency and minimum white noise. Don't hesitate to loose a watt or two of output if a large current savings or white noise reduction can be obtained. The reduced current will result in increased long term reliability!

Tuning the system duplexer while the repeater transmitter is activated can cause very high VSWR conditions to be presented to the final amplifier stage. Always observe final collector current (on the front panel meter) when tuning the duplexer, and keep transmissions short when VSWR conditions are high.

REPLACING TRANSMIT CRYSTAL: If the crystal is replaced and it cannot be zeroed on frequency, change the value of C269 on the terminals near the crystal. If the TX frequency is too high, increase the value of C269. If it is too low, decrease the value of C269. (Typical range: 50 to 400pF.)

5.2 SETTING TRANSMITTER DEVIATION: SCR1000 Repeater
Set front panel RPT. AUDIO pot at full CW. Apply a strong signal to the receiver input (100 µV min.) modulated ±5KHz with a 1KHz tone. Set the DEVIATION Adj. pot (R212) for the desired max. deviation. (Typically 6 or 5KHz MAX.) Then set the RPT. AUDIO pot at the 12 o'clock position. Set the generator dev. for ± 4KHz, and set the A.F. Input Level pot (R218) for 4KHz transmitter deviation.