



SPECTRUM COMMUNICATIONS

SCR200A RX

OPERATION AND MAINTENANCE MANUAL

SCR 1000 VHF FM REPEATER AND FULL DUPLEX BASE STATION

"State of the Art in FM Repeaters"

LIMITED WARRANTY
SPECTRUM COMMUNICATIONS WARRANTY

Spectrum Communications warrants its equipment to be free from defective material or factory workmanship and agrees to remedy any such defect by repair or replacement at the company's option, which in the company's judgement is a fault of its manufacturing, for a period of 180 days from date of original receipt by the original purchaser, provided that the equipment is returned to the factory or its authorized dealer intact and with all transportation charges prepaid. If a malfunction is suspected, write in detail to our service department for suggestions concerning the operation, repair, or return of the unit if this should prove necessary. Do not return equipment to the factory without authorization!

This warranty shall be invalid in the event of (a) unauthorized repair or alteration of any kind, (b) misuse, negligence or accident, (c) connection, installation, or operation in a manner at variance with the instruction manual, (d) alteration, disfigurement or removal of the serial number, or (e) use with accessories not manufactured or recommended by us.

Any part of a unit approved for remedy or exchange will be remedied or exchanged by Spectrum Communications or its authorized dealer without charge to the owner.

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This warranty is in lieu of all other warranties expressed or implied and no representative or person is authorized to assume for us any other liability in connection with the sale of our products.

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OPERATION AND MAINTENANCE MANUAL

SCR 1000 VHF FM REPEATER AND FULL DUPLEX BASE STATION



'Advanced Communications Electronics'

SPECTRUM COMMUNICATIONS

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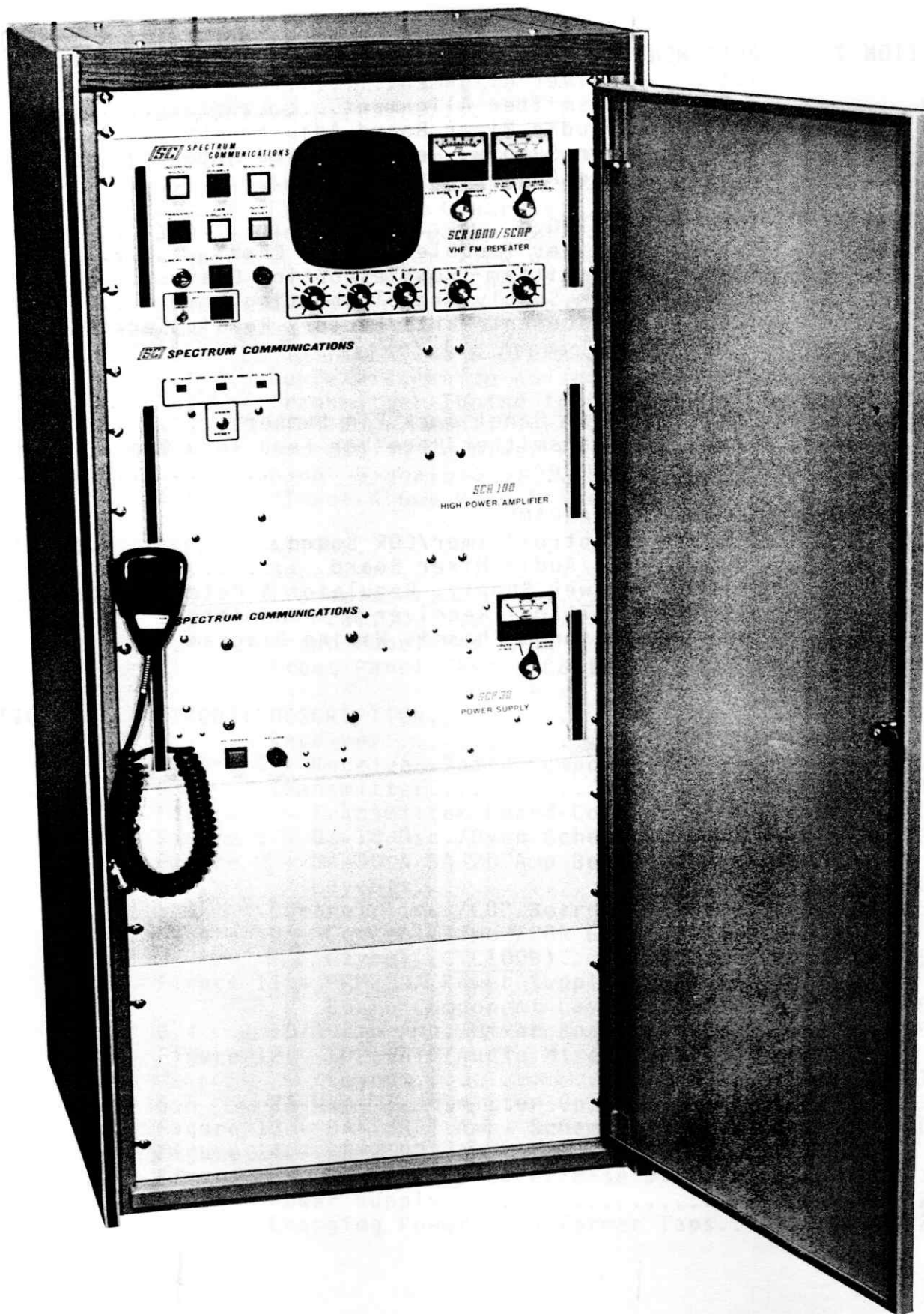
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FIGURE 1 - THE SCR1000 - STATE OF THE ART IN FM REPEATERS
 SHOWN WITH SCR1000V - 150 WATT POWER AMPLIFIER



**FIGURE 1 - THE SCR1000 - STATE OF THE ART IN FM REPEATERS
SHOWN WITH SCA100V - 150 WATT POWER AMPLIFIER**



SECTION 1 INTRODUCTION

We would like to take this opportunity to thank you for becoming one of the discerning individuals or organizations to own the Spectrum Communications' SCR1000 VHF FM Repeater. This instrument represents a state of the art achievement, and embodies thousands of hours of engineering time. Our company is dedicated to the development of very high quality products, manufactured in limited quantities, and we anticipate that they will always be in short supply. Only the finest quality components and workmanship are used throughout the SCR1000. The components are carefully selected and derated for many years of trouble-free operation. The unit is 100% solid-state and is designed for continuous duty, unattended service. The control, timer, and ID boards all use CMOS logic IC's for long, reliable life. (No relays are used in the system.) Many front panel and "on board" controls, status indicators, and 2 panel meters are provided for operator convenience to facilitate initial set-up and long-term maintenance. 2 jacks are mounted on the back panel and include provisions for remote control, autopatch, DC outputs, AF Inputs, and outputs, etc. 2 binding posts are also provided for automatic emergency DC battery power in the event of an AC power failure. An AC power supply and digital CW ID'er are built-in.

SECTION 2 UNPACKING

Carefully unpack the repeater and *save the packing material*. Locate the local mic and 2 connectors supplied.

In case of damage - be sure to notify the delivering carrier at once. All shipments are insured for full value, and damages are the responsibility of the freight common carrier. Our equipment is carefully packed and shipped in perfect condition, and our responsibility for damage ends when the carton is delivered to the carrier.

SECTION 3 OPERATING CONTROLS & INSTRUCTIONS

Always have a 50 ohm load connected to the transmitter output *before* turning on the AC power as the transmitter will come up in the *transmit* mode if the Squelch control is turned fully CCW. Connect the local mic (supplied) to the front panel connector. Connect the receiver input. (Normally from a duplexer.) Plug the line cord into a source of 115-120V, 50-60Hz power. (Or, 220V 50-60Hz if unit is so wired.)

After AC power is energized, all of the meter readings, except the Receiver functions, should be logged for future reference. The readings can be extremely helpful in the future for maintenance or troubleshooting tests.

3.2 FRONT PANEL CONTROLS

- 3.2.1 AC POWER - activates or deactivates AC line power. (Light indicates power on.)
- 3.2.2 AC LINE - 3A AC line fuse - (For 30W Unit). 4A for 75W (&65W) Units. **IMPORTANT!!- DO NOT USE LARGER VALUES!**
- 3.2.3 INCOMING SIGNAL - Indicates the presence of an incoming signal to the COR circuitry.
- 3.2.4 TRANSMIT LIGHT - Indicates that the transmitter is activated and "On the Air". (Actually triggered from the Exciter B+ line.)
- 3.2.5 COR DISABLE - When this button is pushed, (and the lamp is illuminated), the COR circuitry is disabled. An incoming signal may be monitored on the local speaker and signal level meter, but it will not trigger the repeater transmitter. Note that when the COR is disabled, the ID'er and local mic can still bring-up the repeater transmitter. Also, in this position, the unit may be operated as a full duplex Base Station.
- 3.2.6 COR SIMULATE - This pushbutton will trigger the COR circuitry, and simulate an incoming signal to the switching circuits. This is very useful for repeater testing purposes, as it brings-up the transmitter and permits the other front-panel controls to be tested. A push-on, push-off switch is used, and will remain *activated* until the button is pushed a *second* time and the light goes off. While activated, the Time-Out timer may be set, and the INHIBIT-RESET and COR DISABLE functions checked. When released, the HANG TIME may be set. Also, while activated, the Exciter and Final Amp currents and relative outputs may be checked on the meters. The machine is "Timed-Out" when the INCOMING SIGNAL lamp is lit, but the TRANSMITTER light is out - (assuming the repeater is not in INHIBIT mode.)
- 3.2.7 INHIBIT-RESET - This pushbutton/indicator performs a double function. 1.) Positive local control of the repeater transmitter. When pushed, (and illuminated), the transmitter is shut-down and cannot be brought up by *any* means, (except the local mic PTT button.) 2.) If the transmitter has been *remotely* inhibited, this lamp will be illuminated to display this condition of the internal logic circuits. The Inhibit mode, (either remote or locally initiated), may be Reset by pushing this button. (Light goes out.)
- 3.2.8 MANUAL ID - When pushed, this button instantly brings up the CW ID without waiting for the normal time interval. The light indicates that the ID is on, (whether manually or automatically activated). This control is very useful for setting the various ID board controls. If the button is held in, the unit will ID continuously until the button is released. (Pushing this button will *not* upset the normal ID timing interval set by the timer pot on the ID board).

3.2.9 MONITOR VOLUME - Adjusts the receiver audio level to the front panel monitor speaker. (Has *no* effect on repeated audio.) Note that the CW ID is not audible on the local monitor speaker. This control should be set to minimum when the repeater is left unattended.

3.2.10 SQUELCH - Simultaneously sets both the receiver squelch threshold and the COR Trigger point. As the control is advanced clockwise, a stronger signal will be required to trigger the repeater. Since the Squelch/COR circuit is *very sensitive*, it is *not necessary* to set this control on the *very edge of threshold*. Normally it should be set at least 1/8 to 1/4 turn *beyond* threshold. This will still be very sensitive, but will prevent "nuisance triggering" of the machine by extremely weak signals, noise, or other extraneous signals which may be present at the repeater site.

Note that with this "hysteresis" squelch circuit, there is a very beneficial effect with weak, fluttery incoming signals, especially at lower settings of the squelch control. If a signal fades *below* the level necessary to initially "break" the squelch, it would normally "chop-out" of the squelch with most standard receiver designs. However with this circuit, the signal can fade a few dB *below* the opening point before the squelch closes. This has the effect of greatly reducing chopping on weak, fading signals - which can be quite annoying. The hysteresis squelch circuit makes operation of the repeater with weak incoming signals much smoother and much more of a pleasure to operate. Note that the amount of hysteresis (i.e., the difference between the squelch opening and closing levels at a given setting) decreases as the squelch control is advanced.

3.2.11 REPEAT AUDIO - Sets the level of audio from the receiver (only) into the transmitter. This control should be set such that a *received* signal with 4 KHz deviation is *repeated* with exactly 4 KHz deviation also. (The proper setting for 1:1 input-output deviation is with the knob straight-up at the 12 o'clock position. Increasing this control beyond this setting will result in signals being re-transmitted with greater output deviation than input deviation, and consequently, an increase in background noise, hum and distortion. Also, this will drive the repeater audio stages into clipping, (at about 5 KHz of *output* deviation). *Remember* - all FM signals are clipped and filtered at the transceiver. *Any further clipping* at the repeater transmitter only adds needless distortion and *loss of audio quality!* (Note that the repeater transmitter's audio processing stages prevent overdeviation of the repeater transmitter. Max deviation is normally internally set at 5 KHz--- e.g. if an incoming signal has 6-7 KHz deviation, it will be retransmitted at 5 KHz deviation.)

3.2.12 HANG TIME - Sets the repeater transmitter's "carrier hang time" (The amount of time the repeater transmitter stays *on the air after* the received signal drops). Typically set for 4 to 5 sec.

3.2.13 TIME-OUT - Sets the transmitter "time-out time". When the repeater is "timed-out", the transmitter is shut-down after a certain time duration. The time-out may be either on the input (receiver), or output (transmitter) of the repeater per a jumper wire on the COR/TIMER/CONTROL Board. When T.O. is on the input, the timer circuit times the duration of the *incoming signal* and shuts-down the transmitter after the pre-determined time interval has elapsed. The timer resets *instantly* when the incoming signal drops and is reapplied (in this case, the Hang Time is usually several seconds, and there is *no need* to let the repeater carrier drop to reset the timer. Repeater users may reset the timer by merely letting up on their mic button for a fraction of a second). When T.O. is on the output, the timer resets when the *repeater transmitter carrier drops*. In this case, users must let the repeater carrier drop for reset, and hang time is usually fairly short. We recommend T.O. on the input with about 4 sec. hang time. The repeater will be factory set up for T.O. on the input unless otherwise specified.

3.2.14 RF/SIGNAL METER/SWITCH - Reads Transmitter, Exciter and Final Relative RF Output. Readings should be logged for future reference. If readings are significantly different after a period of time, a problem is indicated. Load SWR will affect the readings. The Receiver Signal meter is a relative reading signal strength meter which can be very useful for tests at the repeater site. It operates over the range of signals from "noisy" to "dead full quieting". It is very helpful for tuning duplexers, making antenna adjustments and other tests with a weak received signal, for comparative signal strength checks on repeater users, etc.

3.2.15 VOLT-CURRENT METER/SWITCH - These readings should also be logged for future reference. The 5V and 13.8V readings should be within $\pm\frac{1}{2}$ V. If a sizeable variation is noted in the future, a problem is indicated with that stage.

For the 30 Wt. 136-174MHz Repeater: The normal range of Exciter Current is 1.1 to 1.4A on the 1.5 A scale. The normal range of Final Amp. Current is about 3.0 to 3.6A on the 7.5 scale.

For the 35Wt. 216-240MHz Repeater: The Exciter Current is read as 2X the 1.5A scale; (i.e. 3A Full Scale). Normal current is 2.0 to 2.3A EXC.; 3.7A Final.

For the 75Wt. 136-174MHz & 65Wt. 216-230MHz Repeaters: Both Exciter and Final Current are read as 2X the normal 1.5 and 7.5A scales; (i.e. 3A and 15A Full Scale). Normal Exciter Current is 2.0 - 2.5A, (2.7A on 220MHz). Normal Final Current is 8-9A, and should not exceed 9.5A!

NOTE: For 75Wt. 136-174 MHz Repeaters: See Section 6.5 for detailed information on the 75Wt. unit. (Also for 65Wt. 216-240 MHz.)

3.3 REAR PANEL JACKS

3.3.1 EXTERNAL DC INPUT - EMERGENCY POWER (Red & Black Binding Posts)

This DC input is provided so that the repeater can be operated on an external source of DC power, such as a car or truck battery, should there be a failure in AC line power. Assuming a 12 V battery is connected to the terminals, when the built-in AC power supply's output voltage drops below 11 V, the battery current conducts through the power diode to power the repeater until AC current is restored. The switching action is instantaneous, reliable, and 100% solid state - no manual switches or relays are required.

When the repeater is operating normally on its built-in AC power supply, about 100mA of current is delivered to the battery as a trickle charge. Note: This is *not* enough to charge a discharged battery - only enough to "float" a *fully charged* battery and prevent self-discharge. When the battery is discharged, it must be *disconnected* and charged from a standard battery charger.

The Red terminal is the +12 V input. Black is the ground or - terminal. The input is fused with an 8 A fuse. If the 12 V leads are reversed, the reverse voltage protection diode will conduct very heavily and blow the fuse - thus protecting the repeater from damage. When operating on battery power, the repeater will draw about 5 amps of current while transmitting. At least a 70 Amp-Hour battery is recommended. Keep the battery leads as short as possible (6 to 8 feet *maximum*) and use *at least* #12 wire (#8 or #10 preferred).

In normal operation, the *battery voltage must not exceed 13.0V* or there could be damage to the repeater. If it is desired to run the repeater *strictly* on an external DC Power Supply, disconnect the AC line cord, and in this case *only*, the external DC voltage may be as high as 14.6V.

3.3.2 ACCESSORY JACKS J602 & J603

These jacks are provided for convenience in interfacing the repeater to other auxiliary equipment and for test purposes. See Table 2 for the pin configurations.

J603 includes pins for +5 and +13.8 VDC output to power auxiliary equipment ($\frac{1}{2}$ A max. each - continuous). There are also two pins for remote repeater transmitter control. With this feature, the repeater transmitter may be Inhibited (shutdown) or Reset (to normal operation) remotely - a very useful feature. When inhibited, the transmitter cannot be brought up by *any* means (except the local microphone). Note that the front panel Inhibit-Reset lighted push-button switch performs this same control function *locally* (the indicator lamp is illuminated when the repeater is in Inhibit mode).

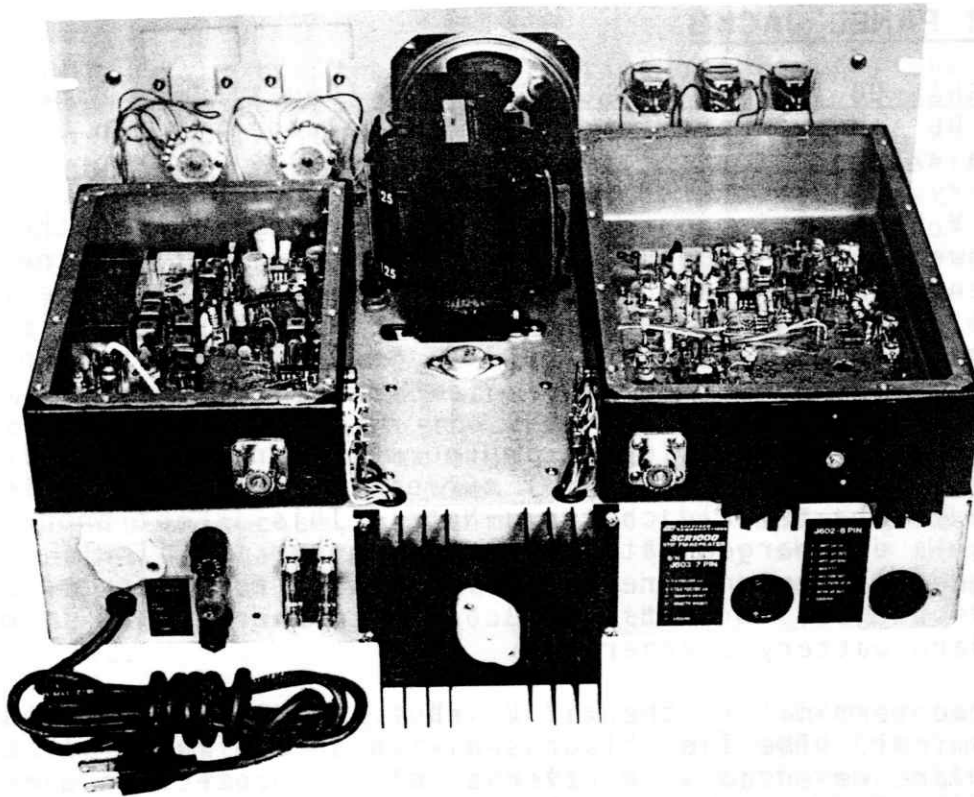


FIGURE 2 - REAR VIEW OF THE SCR1000

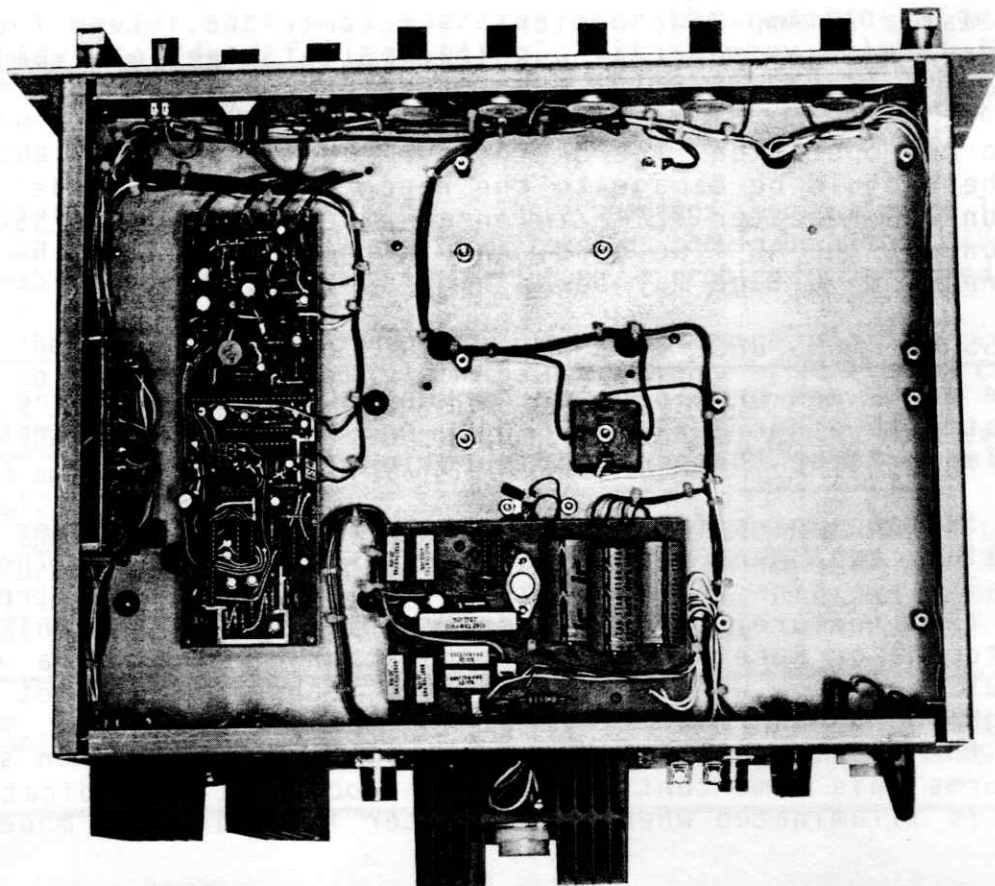


FIGURE 3 - UNDER CHASSIS VIEW SHOWING COR , ID , AND POWER SUPPLY BOARDS

A positive-going standard 4-5 V logic level trigger pulse is required to trigger the Inhibit-Reset circuitry. (The circuit triggers on the *leading edge* of a fast rise time pulse.) This trigger pulse may be the output TTL level pulse of a Touch Tone decoder (such as the Spectrum TTC300), other digital circuitry, a simple transistor switch, or even relay contacts connected between the Reset and Inhibit pins and the +5 V supply. A single pulse into the Inhibit pin will instantly shut down the transmitter. The transmitter will remain in Inhibit mode until a trigger pulse is applied to the Reset pin-which will instantly reset the control circuits to normal operation.

J602 includes pins for Audio Inputs and Outputs, transmitter keying (PTT) and COR switching. These connections are very useful for interfacing equipment such as an Autopatch, TT Decoder, or external source of audio input to the repeater transmitter.

Pins 1, 2, and 3 bring Repeat Audio out of, and back into the repeater. (Repeat Audio is the audio out of the receiver which modulates the transmitter.) Pins 1 and 2 are normally jumpered together, but this connection may be opened for autopatch or other use. Also, with proper external circuitry (Such as a DIP relay or transmission gate), repeat audio could be *muted* for the duration of a touch-tone autopatch turn-on swquence so that these tones are not repeated. Shielded wire *must* be used for these connections, and pin 3 used for the shield ground connections. (Pin 3 is not directly grounded at the jack in order to eliminate hum-producing "ground loops". It *is* connected to chassis ground at the far end of the internal shielded wires.) In order to keep hum to a minimum, only low-level audio signal grounds should be connected to Pin 3 (i.e. not DC ground, etc.).

Pin 4 - *Ground* this pin to trigger the transmitter remotely (may be grounded through the collector of an NPN switching transistor such as a 2N2222A, or through relay contacts, etc.). Triggering the transmitter for *any length* of time via Pin 4 *will not* cause the transmitter to "time out".

Pin 5 - This is an open collector transistor switch which is triggered by the COR - (switches ON--or "low" -- when there is an incoming signal to the receiver). Useful for autopatch and many other applications.

Pin 6 - Auxiliary Audio Input to the transmitter. (Level Adjust pot is on the ID & Audio Mixer Board). Maximum input sensitivity is 100mVp-p (36Vrms) for +5KHz transmitter deviation with a 1 KHz tone. Use shielded wire on pin 6 and use pin 3 for ground. Useful for autopatch or any other application which requires voice or tone audio to modulate the repeater's transmitter.

Pin 7 - Receiver Audio Output (High Impedance line), *after* squelch gate. Maximum output level: 0.6 Vp-p (0.22 Vrms) w/1 KHz tone @ +5 KHz deviation. *Do not* load down this terminal with low impedance loads. Use at least a 10K ohm load impedance *or greater*. (10K ohm pot, etc.) Shielded wire *is required* for connection to this point. Use pin 8 for ground.

Pin 8 - Chassis Ground.

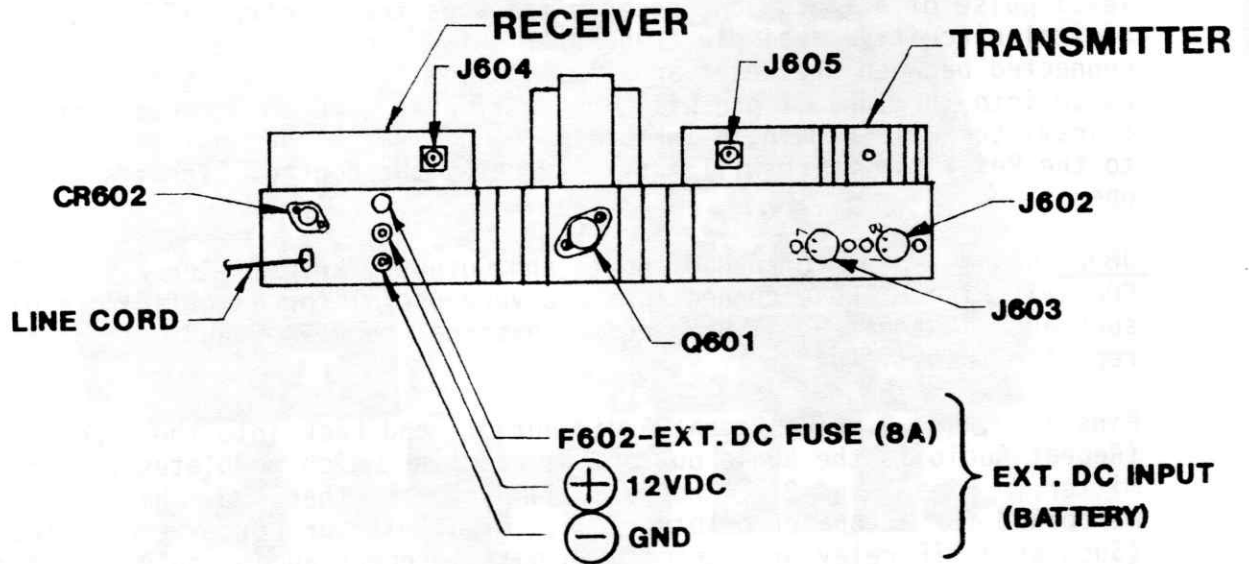


FIGURE 4

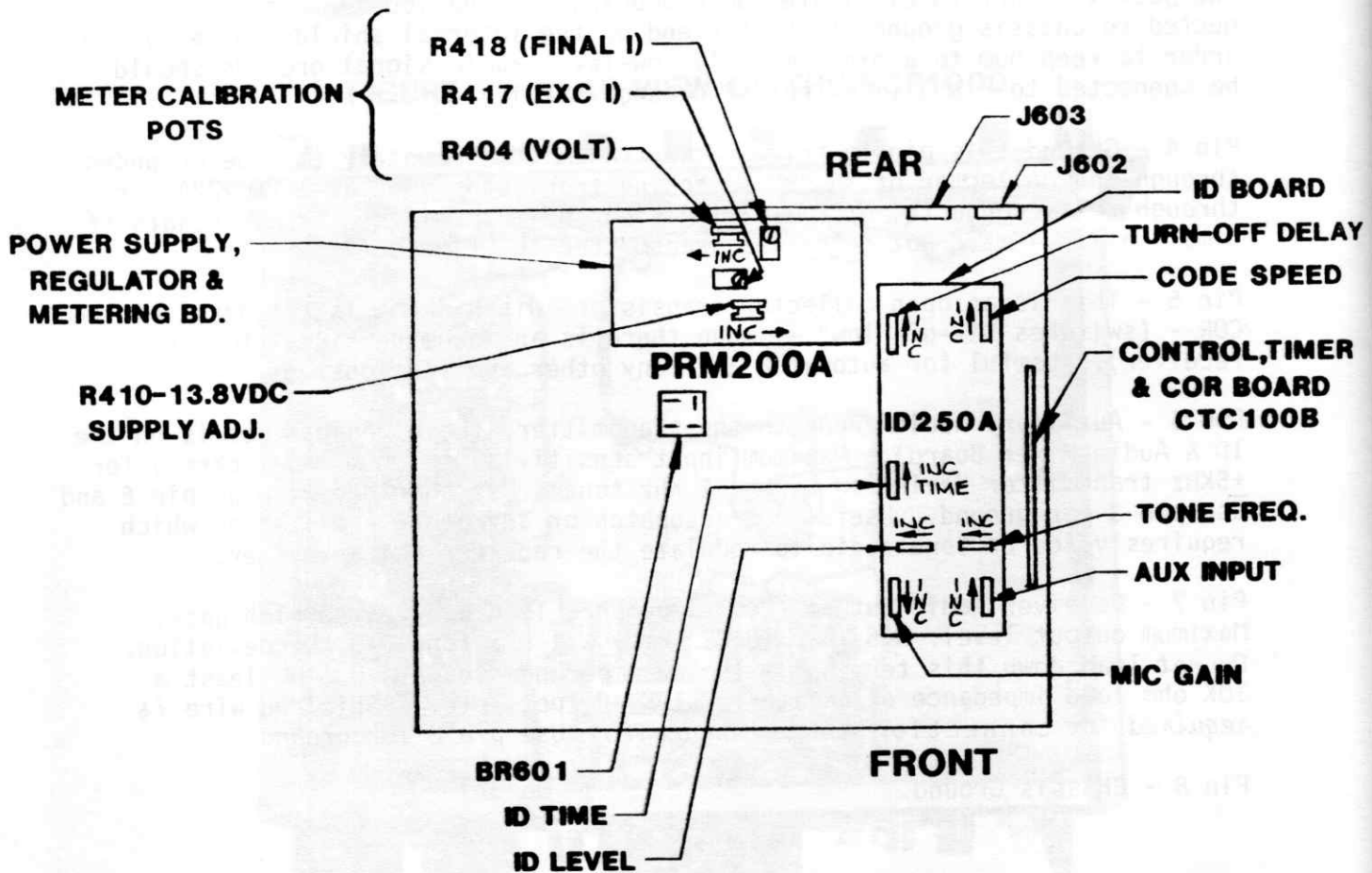


FIGURE 5

SCR1000 CHASSIS LAYOUT

SECTION 4 REPEATER INSTALLATION & OPERATION

4.1 DUPLEXERS, WHITE NOISE, "DESENSE", ETC.

We recommend a good quality duplexer with approximately 90 dB isolation and silver-plated cavity center conductors. Duplexers with a bandpass/bandreject response are highly recommended. Each repeater transmitter is carefully checked on a spectrum analyzer before it is shipped, and white noise is at least 90 dB down @ ± 6 MHz. Spurious outputs are at least 70 dB down. Note that transmitter "white noise" is low level wideband noise that is generated in *all* types of oscillator, multiplier and amplifier stages. This noise will be found to varying degrees in *all* transmitters. If not properly filtered out by the duplexer, this noise can mask weak received signals.

System performance may be computed as follows:

+ 45dBm	30 Wts. Output (Note: 0dBm = 1mW)
<u>-90dB</u>	White Noise is 90dB below carrier
-45dBm	Absolute Level of Noise
<u>-90dB</u>	Duplexer isolation to receiver port
-135dBm	Level of white noise at receiver port

This is *below* minimum detectable signal level of the receiver.

Transmitter white noise is best checked with a steady, weak signal into the repeater system (20 to 30dB of quieting) with duplexer and antenna connected. Listen on the local monitor speaker, and alternately push the COR Disable switch on and off, while listening for an increase in noise which may mask the weak signal. (Reduce Hang Time to zero.) If an increase in noise is heard when the transmitter is activated, it is most likely *not* "desense" as is commonly believed, but transmitter white noise getting back into the receiver due to insufficient isolation in the duplexer. The extremely wide dynamic range of the Spec Comm receiver *precludes true desensitization* of the receiver due to overload by the transmit carrier *unless* the duplexer is greatly out of tune, or, where two antennas are used and there is insufficient separation. (80dB minimum - 100 ft. vertical separation min.-recommended.)

4.1.1 DUPLEXER TUNING

If transmitter white noise is a problem, the duplexer may have to be tuned slightly into your system since different cable lengths and antenna VSWR can affect cavity tuning. (Antenna VSWR must be under 1.4:1 for a duplexer to operate properly.) If cavity tuning is required, carefully tune the "Transmitter" cavities for minimum noise on the weak signal, consistent with maximum power out to the antenna. (Note: *Only double shielded* coax cable should be used in the system - such as RG-9B/U or RG-214/U. *Do not* use the commonly available "loose braid" coax such as "RG8 Type". Keep cables at least one foot apart. It is recommended that the cavity tuning rods be measured or

marked, so that you can return to the original settings if required.

4.2 TRANSMITTER TUNING FOR MINIMUM WHITE NOISE

If the duplexer has been tuned and some white noise remains, it may be necessary to tune the repeater transmitter for minimum noise. Again, this should be done with a weak, steady received signal which is monitored on the local speaker while the COR Disable button is pushed on and off. The coils and the various trimmer caps should be carefully tuned for minimum white noise consistent with maximum output power (preferably with a Bird wattmeter, or equivalent, at the output of the duplexer). The coils should be tuned ± 1 turn, or ± 2 turns, and the effect noted. *If there is no effect, return to the original setting.* If necessary, the ceramic trimmer caps may be adjusted - a fraction of a turn only. Driver and final amp trimmers are adjusted for maximum output consistent with minimum white noise and minimum current.

If all else fails, any remaining white noise can normally be eliminated by the addition of one or more cavities (notch type) to the *Transmit* side of the duplexer. This will pass the transmit carrier, but notch-out white noise on the receive frequency.

4.3 HIGH POWER AMPLIFIERS - SUCH AS SPECTRUM 150 WATT SCA100V

If it is desired to add an amplifier to the repeater transmitter's output, with 70-150 watts output, one additional cavity (notch type) may be required in the Transmit side of the duplexer. It is a little recognized fact that transmitting amplifiers (like receiving pre-amps) have gain, and a noise figure - which is typically about 30 dB for solid state amps! In other words, while the amplifier will provide 5 to 8 dB of gain, it will also increase white noise by about 30 dB. If this is a problem, the only solution is an additional transmitter notch cavity, which will supply about 30 dB of increased filtering of white noise between transmitter and receiver.

4.4 INCREASING RECEIVER REJECTION OF "OUT-OF-BAND" SIGNALS

The Spectrum Receiver incorporates one of the "sharpest" and widest dynamic range front-end designs on the market, but even so, if the repeater antenna is located at a site with many nearby VHF transmitters, additional front-end filtering may be required to prevent spurious mixing products (a filter should be planned into the system in advance in this case). Transmitters within ± 20 MHz will usually be the biggest problem. Remember - most duplexers have *little or no out of band rejection* - only a notch on the transmit frequency, so do not rely on the duplexer for out of band filtering; *with the exception of the bandpass/band-reject type* which is supplied by Spectrum Communications Corporation.

If spurious received signals or "desense"/front-end overload is a problem due to nearby VHF transmitters, (sometimes producing extreme received levels of *several hundred-thousand microvolts!*), the only solution is a good quality cavity *filter* in the receiver input line. In general, a Bandpass Filter is recommended as this will greatly attenuate everything beyond about ± 5 MHz. For "closer-in" interference, or where there is only 1 interfering signal, a "Notch Type Filter" is usually preferable. Contact Spectrum Communications for further details. Our FL-6 Pre-selector is highly recommended to "filter out" strong signals more than 4 MHz away.

4.5 "TOWER & GUY WIRE NOISE"

In some single-site repeater installations, there may be a problem with intermittent "crackling noises" on the repeater signal, (particularly on weak received signals), especially when there are high winds. This noise has been traced to poor and intermittent metal to metal connections on the antenna tower or nearby metal objects - such as guy wire connection points, tower leg joints, supporting mast intermittently touching the tower's top collar, rusty joints, etc. These metal objects pick up RF from the repeater's transmitted signal, and when moved slightly, will *arc* microscopically to any other metal object touching it. The arc, (which is a very low level effect), produces a wideband RF noise which is radiated, picked up by the repeater's antenna, and heard in the receiver - which is, of course, then re-transmitted.

One stubborn case was traced to a point where a rusty steel supporting mast passed through the collar at the top of a tower, only a few feet below the repeater antenna. The cure to the intermittent connection, which produced a heavy static on windy days, was rather unique. The tower collar was packed with automotive lithium "chassis lubricant"! This grease is very lossy at VHF, and effectively 'shorted-out' the poor connection, and eliminated the noise from that source.

The solution to these intermittent joints is to either bond or insulate the poor connections. Bonding involves either clamping, soldering, or welding the connections together. Wire braid, copper strap, heavy wire, etc., may be used. Any materials which can rust *must not* be used since rusty joints are the *worst* offenders. Once bonded, the connections should be waterproofed with a material such as the commonly available "Silicon Rubber." As an alternative, the connections may be insulated. Guy wires should be insulated with ceramic compression insulators only about 1" from each tower leg. Any wire or metal objects within about 50' of the antenna should not touch each other! Also, beware of "noise" on the repeater's output due to intermittent cable or antenna connections! Some fiberglass encased 6 dB gain base station antennas are known to become *internally intermittent* after as little as 2 years service - thus producing a terrific noise on the transmitted signal! (Check for intermittent VSWR.)