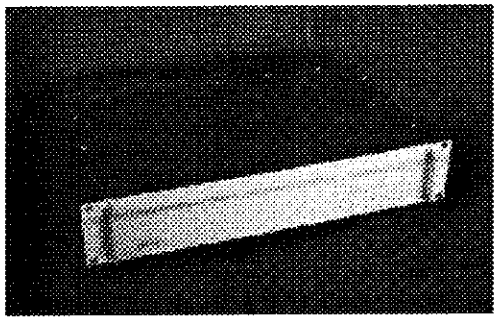
RELM Communications, Inc.
S SERIES RF TRANSCEIVER



USER MANUAL

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Applicable reference:

Micro-controller Board Rev C
S Series Utility Software ver 1.0

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All quoted performance figures are typical and are subject to normal manufacturing and service tolerances.

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Record of Revisions

Any changes to this manual are recorded on this list.

Date	Manual Version	Chapter Changes	Pages Changed
May 1998	1.0	All—Initial Release	All

SAFETY SUMMARY

Although there are no dangerous high voltages present within the equipment, the following general safety precautions must be observed during all phases of operation, service, and repair of this equipment.

PROTECT THE EQUIPMENT.
To minimize any possible shock hazard from an external power supply or lightning strike, the chassis or equipment cabinet must be connected to an electrical ground. Provide adequate ventilation around the rear of the equipment.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.
Do not operate the equipment in the presence of flammable gases or fumes. Operation of any electrical equipment in such an environment constitutes a definite safety hazard.

DO NOT ATTEMPT INTERNAL SERVICE WHILE TRANSMITTING.
Thermal or RF burns may result from touching certain components within the power amplifier module while transmitting or operating the transmitter.

DO NOT SUBSTITUTE PARTS OR MODIFY THE EQUIPMENT.
Because of the danger of introducing additional hazards, do not install substitute or lower voltage parts to the equipment. Return to your authorized distributor.

EXERCISE CAUTION AND CORRECT DISPOSAL OF RF POWER DEVICES.
Most RF power transistors and some RF power hybrids contain Beryllium Oxide. Although these transistors are normally safe, if physically damaged, toxic dust could be released. Consult your local authority for correct disposal thereof.

Contents

Introduction

The S Series of radio systems uses state-of-the-art design and construction methods to deliver a range of high-performance, ultra-reliable radio devices. These radio systems are ideally suited for use in VHF or UHF two-way voice radio systems; however, the S Series can perform any number of applications where the added advantage of linear frequency and phase response from DC to 5KHz can be used. The S Series, unlike conventional PLL radio systems, uses a two-point modulation method synthesizer for extended low-end VF transmit frequency response.

The flexibility of the S Series allows it to be configured for a wide range of applications:

- Standard or wideband voice, full duplex radio
- Cellular or trunking systems
- POCSAG paging transmitter
- Direct FSK modulation
- Two- or four-level FSK transmissions
- Other paging formats
- Cross band link or repeater

General Description

The S Series of radio systems features a high degree of RFI (Radio Frequency Interference) and EMI (Electro-Magnetic Interference) screening throughout its design and construction. The receiver and exciter (low-power transmitter) modules are contained in a solid machined aluminum enclosure, and for additional screening, each interface pin is individually filtered. The PA (Power Amplifier) module is contained in a special compact extrusion for minimum harmonic radiation. In addition, the RF (Radio Frequency) modules and the micro-controller are also contained in the main screened 2RU (Rack Unit) case for low conducted and radiated emissions and minimal susceptibility to RFI and EMI.

The S Series consists of four main sub assemblies: an exciter module, a receiver module, a power amplifier module, and a micro-controller board. For further information on these sub assemblies, refer to the Technical Description section later in this manual.

Exciter Module Description

The exciter module features a modulation bandwidth to DC (Direct Current) with an ultra-wide RF bandwidth 20MHz–1000MHz at an output power of 300mW. To change from one band to another, all you need to do is change the plug in the VCO board; no other manual adjustment or change is required. If a high stability reference is required, the RF modules can be fitted with connectors for an external reference oscillator input. On-board memory stores calibration, personality information, and program data. Alternatively, the exciter module can be set up as a conventional PLL (Phase Locked Loop) if simplicity and minimum cost are required. The fractional N synthesizer provides ultra low spurious while still maintaining fast lock times, even at 6.25KHz step size or less. An optional built turn-around mixer (TRM) provides advanced diagnostics such as receiver sensitivity tests.

Receiver Module Description

The receiver module features the same advanced synthesizer and wide bandwidth as the exciter. Only the front end bandpass filter and VCO (Voltage Controlled Oscillator) need to be changed to support different frequency bands, resulting in significant flexibility and end-user cost savings. The custom-built front end bandpass filter has a wide no-adjust bandwidth equal to the band allocation. The receiver has extremely high sensitivity while maintaining excellent intermodulation immunity and adjacent channel rejection. A double first IF (Intermediate Frequency) provides excellent rejection to commonly known spurious responses. High blocking of over 120dB typical ensures that strong interfering signals do not desensitize the receiver when receiving weak signals.

Power Amplifier Module Description

The PA is very compact and efficient for high reliability and low cost. The heatsink has minimal temperature rise even under continuous operation. This also ensures the best MTBF (Mean Time Between Failure) obtainable for a practical design. A low-loss 13-element elliptical low-pass filter ensures that any harmonics remain below –100dBc.

Key Features and Advantages

- Exceptional system performance
- Modular internal construction
- Software or hardware configurable
- 50 Watt continuous transmitter (30 Watt above 800 MHz)
- Programming via RS232
- 256 channel capacity
- Optional CTCSS (Continuous Tone Coded Squelch System)
- Paging capability
- VF filters and processing can be bypassed
- Fast mute
- 20mS Rx (Receiver) and TX (Transmitter), 4mS selectable
- Front panel display
- Digital squelch compatible
- Wide band Rx and TX
- Isolated PTT (Push To Talk) input
- Digitally controlled and corrected TX deviation
- Programmable TX power
- Direct FSK (Frequency Shift Keying) or paging compatible
- VSWR (Voltage Standing Wave Ratio) and Temp protection
- Compact 2RU case
- 13.8 Volt operation
- Available in continuous coverage from 66 to 88MHz, 135 to 520MHz, and 805 to 960MHz
- Surface mount technology used throughout
- Rear analog and digital interfaces

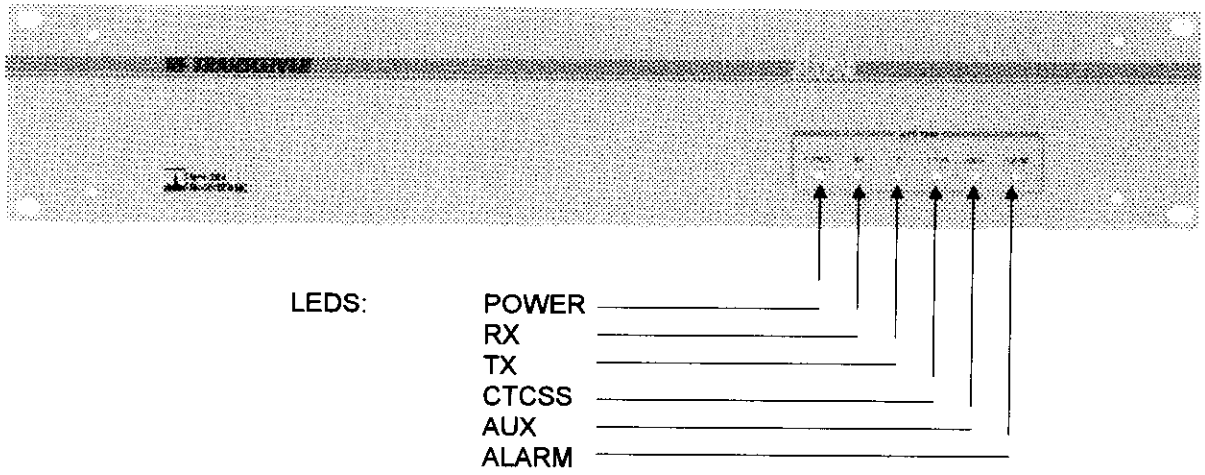
Other options and variations are available. Please consult RELM Communications for further details.

Indicators and Connectors

The S Series can be supplied with custom front panels. The standard version is shown below.
The following tables explain the functions of the front panel LED's. Each LED indicates the status of the S Series Base Station in real time.

Standard Version Front Panel

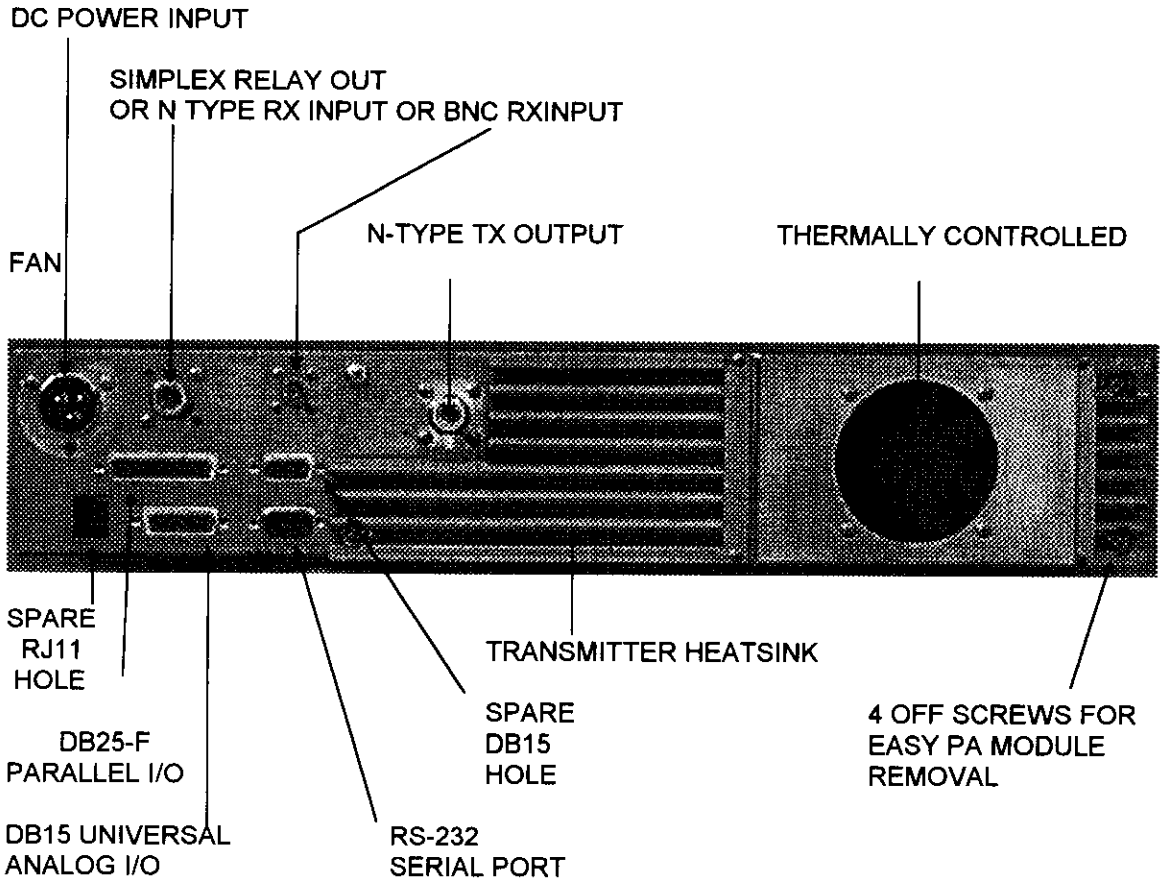
LED	FUNCTION
POWER	The power supply voltage is within software selectable limits.
RX	A signal is being received by the receiver or the receiver squelch is open.
TX	The transmitter is transmitting RF power.
CTCSS	A valid Continuous Tone Coded Squelch Signal has been detected.
AUX	The aux function is selected, or the PLL is unlocked.
ALARM	A general alarm condition exists such as under/over voltage or over temperature.



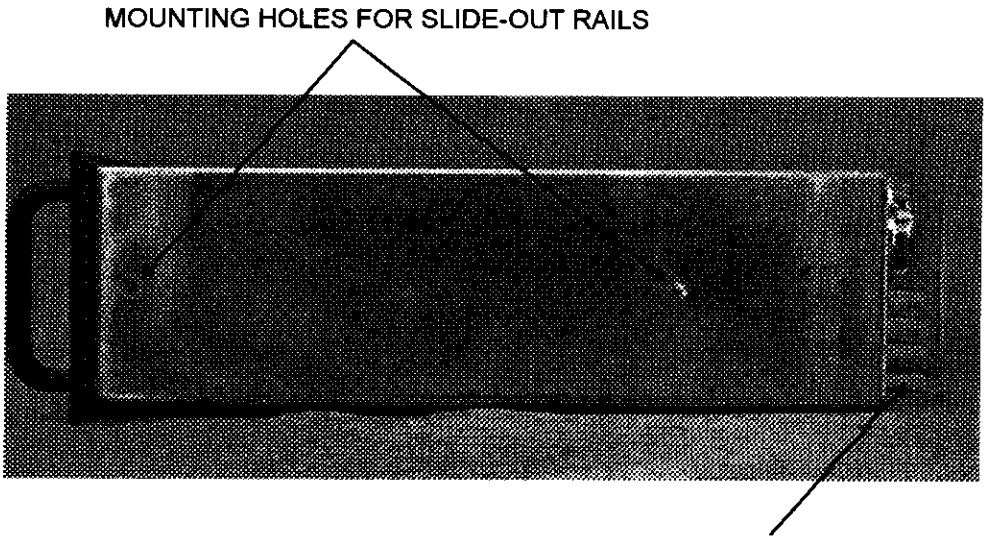
Rear Panel Connectors

CONNECTOR	DESCRIPTION
DC POWER INPUT	13.8 Volt DC power input. Also +28 Volt input on spare pin.
SIMPLEX RELAY OUT OR N-TYPE RX INPUT	Location for internal simplex relay. The antenna for RX/TX connects to this point. Or an N-type connector can be used for the input to the receiver for full duplex operation.
BNC RX INPUT	Standard BNC connector for the input to the receiver for full duplex operation.
N TYPE TX OUTPUT	The RF power output from the transmitter for full duplex operation.
SPARE RJ11	Provision for internal expansion.
DB25-F PARALLEL I/O	Provides two 8-bit input ports, where one is used as the parallel BCD channel select. Also one spare 8-bit input port.
DB15 UNIVERSAL ANALOG I/O	Provides the necessary analog receiver and transmitter interface for system expansion.
RS-232 SERIAL PORT	9600 baud serial port for frequency programming, channel selection, and alarm and status monitoring.
SPARE DB15	Provision for internal expansion.

Rear View S Series



Side View S Series



Installation

WARNING: Observe all safety precautions when working with electrical and electronic equipment. Contact Spectra Engineering if you are in any doubt about the suitability of your test environment.

S Series radio systems are securely packed for transport in polystyrene foam peanuts inside a pasteboard container. Before unpacking the S Series radio, please inspect the packaging for signs of damage, and report any damage to your S Series distributor.

As you unpack the S Series radio, make sure you received all items shipped. Report any missing items to your S Series distributor. All ports on the rear of the radio should be carefully examined to ensure that packaging has not become wedged inside them. It is very important to examine the fan because operation of the radio will be affected if any packaging causes the fan to stop working.

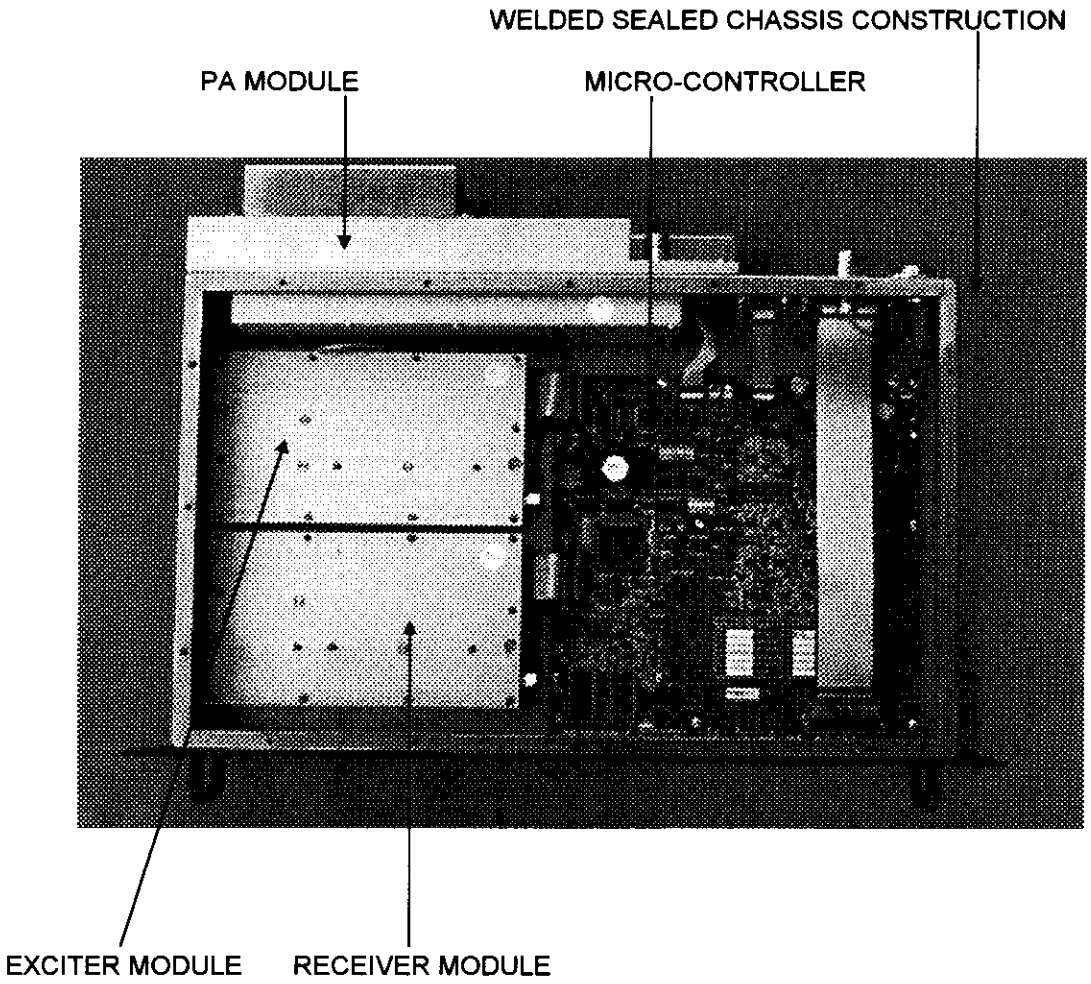
If you intend to install the radio in an equipment rack, consult the installation manual for your system. Spectra Engineering recommends that the radio be secured into the rack system using four screws through the mounting holes in the front panel, near the handles.

If the radio is to be used in a stand-alone configuration, be sure the radio is in a secure, dry location with sufficient air space to allow for adequate ventilation.

Technical Description

Internal Connections

The internal design of the S Series is of a modular nature, allowing for simple configuration and maintenance while ensuring minimal downtime. For reference purposes, an image of a typical S Series system is shown below.



Exciter Module Technical Description

RF from the VCO, at a nominal level of +3dBm, is applied to the fractional-N synthesizer IC (Integrated Circuit) main divider input. A second, separate RF output of the same level from the VCO is used as the main transmit RF amplifier signal source. The main signal is first buffered by a very high isolation circuit consisting of a 10dB pad and a MMIC (microwave Monolithic Integrated Circuit) amplifier. The signal is further amplified by a variable-gain wide-band amplifier with a 40dB control range and a power output of 300mW. The drive power of this stage is used to set the output power of the main power amplifier. The output of the charge pump of the synthesizer is filtered, then amplified by the noninverting low-noise op amp. The op amp uses a 25-volt power supply to provide a wide tuning range voltage to the frequency control varicaps located on the VCO board.

The VCO boards and synthesizer circuits are the same for the exciter and receiver modules. The VCO consists of a 10mm ceramic coaxial resonator with a common base oscillator for low-phase noise for bands 805–960 MHz. Frequencies below 520 MHz use an LC tank circuit. The power supply to the VCO consists of a its own 8-volt regulator and active filter for maximum noise rejection. For standard modulation, transmit audio is fed to the conventional point of the VCO varactor. For two-point modulation, audio is also fed to the voltage control pin of the VC-TXCO (Voltage-Controlled Temperature-Compensated Crystal Oscillator). This in effect cancels out the PLL error that would otherwise have occurred for low audio frequencies, resulting in a flat VF (Voice Frequency) response.

Receiver Module Technical Description

The receive signal from the antenna enters a three-section band pass filter (BPF) that provides the initial filtering for the front end amplifier. The front end amplifier is a broad-band high-performance MMIC with a gain of 20dB, NF (Noise Filter) of 4dB, and 3rd OIP (Third Order Intercept Point) of +36dB. This is then followed by the second three-section BPF, then a high-level double-balanced mixer. RF from the VCO is buffered and amplified to +17dBm and injected in the high-level mixer, which down converts the signal to the IF frequency of 90 MHz. The IF signal of 90 MHz from the mixer is terminated by a bi-directional constant-impedance diplexer network and is then amplified by a bipolar amplifier with a gain of 15dB and 3rd OIP of +35dB. This provides a high degree of intermodulation rejection for the receiver. This stage is followed by a four-pole 90 MHz crystal filter with its associated matching networks. The signal is further amplified and filtered by a transistor and its associated two-pole crystal filter before being fed into the main IF demodulator chip with a second IF frequency of 455 KHz. The resulting audio is passed out to the micro-controller board.

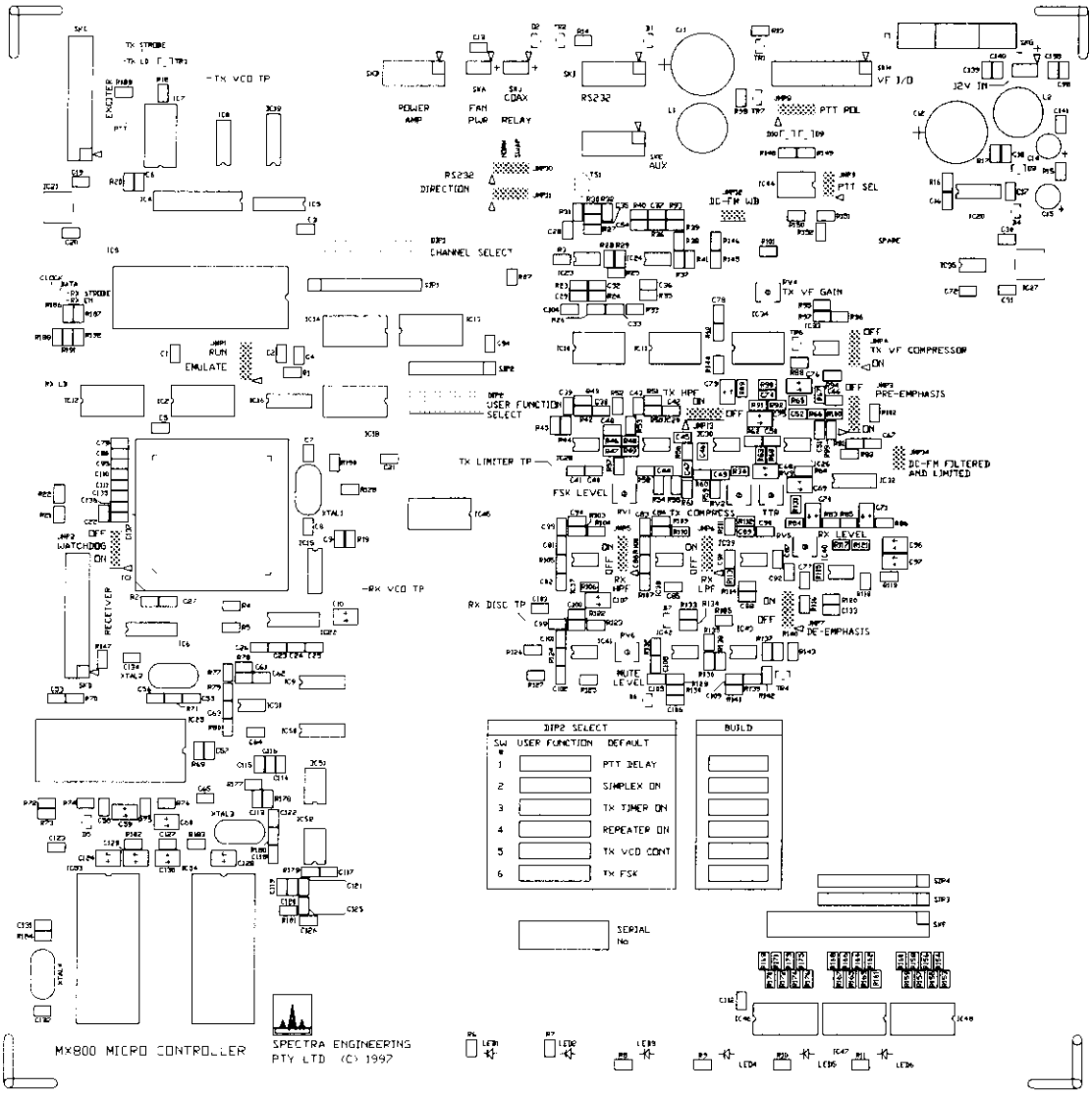
PA Module Technical Description

RF from the exciter is first attenuated by a 50-ohm pad that provides a good 50-ohm source impedance for the high-power hybrid amplifier. The RF is amplified to 5–13 watts at its 50-ohm output. The signal from the hybrid is then matched by a broad-band network to drive the low-input impedance associated with the final transmit power amplifier transistor. The low collector impedance of the transistor is then also matched back to 50 ohms with a broad-band matching network. Several trimmer capacitors allow you to adjust the power amplifier over a wide bandwidth to maintain good conversion efficiency.

The dual-directional coupler consists of coupled microstrip transmission lines fabricated on the PCB (printed Circuit Board) artwork. The sampled RF energy is rectified to provide a proportional DC voltage output. Prior to transmission, a low-loss 13-element elliptical low-pass filter filters out the unwanted harmonics to less than –100dBc.

Micro-Controller Configuration

The view below is an image of the micro-controller layout and the position of the jumpers and DIP switches (highlighted) that are used for setting the general configuration of the audio filters, PTT functions, and other various facilities.



NOTE: Not all components shown are fitted.

Description of Micro-Controller Jumper Functions

JMP #	FUNCTION / DESCRIPTION
JMP 1	Selects either default RUN or EMULATE mode for the micro-processor
JMP 2	Enables the WATCHDOG auto reset function in the micro-processor
JMP 3	Enables or disables the PRE-EMPHASIS for the TX audio
JMP 4	Enables or disables the COMPRESSOR for the TX audio
JMP 5	Enables or disables the HIGH PASS FILTER for the Rx audio
JMP 6	Enables or disables the LOW PASS FILTER for the Rx audio
JMP 7	Enables or disables the DE-EMPHASIS processing for the Rx audio
JMP 8	Selects a common earth or floating PTT input (See Appendix B)
JMP 9	Selects the PTT mode (See Appendix B)
JMP 10	Controls the direction of the RS-232 TX and Rx data (See the next section and Appendix B)
JMP 11	Controls the direction of the RS-232 TX and Rx data (See the next section and Appendix B)
JMP 12	Enables a direct connection to the TX modulation, not normally used (See Appendix B)
JMP 13	Enables or disables the HIGH PASS FILTER for the TX audio
JMP 14	Enables a direct connection to the TX modulation via the limiter and post LPF (See Appendix B)

Testing

The following equipment is required to test S Series radios:

- A radio communications test set with 600 Ω interfaces
- A digital multimeter
- An oscilloscope
- 13.8V power supply
- A PC with at least 8Mb of RAM, a serial port, and the S Series Base Station Utility software installed.
- A suitable cable to connect the serial port of the PC to the S Series radio RS-232 port (see Appendix B).
- A suitable power lead as supplied with the radio
- Suitable low-loss RF cables and connectors.

CAUTION: **Attempting to operate the transmitter without an appropriate load connected to the RF output could cause physical damage to the unit and void the warranty. Contact Spectra Engineering if you are in any doubt about the suitability of your test environment.**

Connecting a Computer to the S Series Radio

The standard cable used to connect the computer to the S Series is a serial lap-link-type cable. This cable usually consists of a lead with a DB9 and DB25 female connector at each end. The Rx and TX data signals are cross connected in lap-link-type cables. Two jumper links are on the micro-controller circuit board inside the S Series designated JMP10 and JMP11. Their default position is pin 2&3 or "SWAP." This indicates that a lead that swaps Rx and TX data is in use.

Other special serial leads can also be used. To allow for more combinations, you can set JMP10 and JMP11 to position 1&2 or "NORM," which has the effect of swapping over pins 2 and 3 on the DB9 rear connector.

Test Setup

Make all connections at the rear of the S Series radio.

Connect the transmitter RF output located on the heat sink module to the dummy load/TX test input of the Radio Communications Test Set using a short length of low-loss RG 213 or equivalent coaxial cable.

Connect the receiver RF input to the signal generator output of the Radio Communications Test Set using moderate- to low-loss coaxial cable.

Connect all VF interfaces and control lines to the appropriate points.

Connect the S Series Radio to a suitable 13.8 volt DC power supply while observing the correct polarity.

Test Procedure

Refer to Calibration Procedure in this manual.

S Series Base Station Utility

Initial Setup and Description

Main Display Tool Bar Description

The **CHANNEL INFO** button is used to view and set up the frequency information in the S Series.

The **ANALYZE** button reads the internal status of the S Series and displays as such.

The **UPDATE** button is used only when SETUP—DYNAMIC is selected. Pressing **UPDATE** sends the dynamic settings to the S Series for quick initial testing. The values are not saved in the S Series. The **UPDATE** button is also used to set up the default values used in the channel programming.

The other buttons duplicate **SAVE**, **OPEN FILE**, **SEND DATA TO RADIO**, and **LOAD DATA FROM RADIO** as seen on the Channel Info screen, respectively.

Initial Settings

To read or send data to the S Series, you must first create or open a file.

Initial Static Settings

Go to Setup Static, and set the appropriate values and conditions for the S Series. Press **SEND** to send and store the values inside the S Series.

Note: Reference, IF frequencies, and injection are not stored in the S Series, so this must reflect the actual physical conditions of the S Series.

The standard reference oscillator is 14.4MHz. The standard IF is 90MHz with high-side injection bands A to I and low side J to X. The PLL correction factor value is usually around 120. The fan-on temperature is normally set to 40°C with the over-temperature cutout at 70°C.

Channel Programming and Description

At the Channel Info screen, click on the channel you want to set up. You can view all the settings and calibration data; however, you will need to enter the password by clicking the **ADVANCED** button to proceed. This level of protection is provided to advise that changes could allow the transmitter to potentially cause interference to vital radio communications services. See also the Quick Frequency Programming and Full Calibration sections of this manual.

QUICK FREQUENCY PROGRAMMING

If a calibrate has already been performed, go to the Channel Information screen. Click the channel number you want to change or create. Go into advanced mode with the correct password. Enter the frequencies of the channel. Inject an audio signal with sufficient level (~0dBm) to ensure compressor operation, and check that the deviation is 3KHz for 25KHz channel spacing or 1.5KHz for 12.5KHz spacing. Adjust the VCO deviation for the correct level. Most of the other settings will not change. If in doubt, see the Full Calibration section of this manual.

FULL CALIBRATION

TX MODULATION

TX .modulation is the recommended full-calibration procedure with DC–FM installed. You can carry out the alignment in the Setup Dynamic mode for a quicker result. Calibration is performed on the center RF frequency.

1. Set the reference level to 0 and the reference bias to 127.
2. On the S Series micro-controller board, set pre-emphasis, TX HPF, and the TX VF compressor to OFF. Turn the TX compress level RV2 fully clockwise to maximum to allow the hard limiter to operate.
3. Inject a 1KHz audio signal into the TX VF input at a level of +10dBm. Check with an oscilloscope that the audio signal is clipped at the TX limiter test point.
4. Set the VCO level to achieve a 4.8KHz deviation (clipped waveform) for 25KHz channel spacing and 2.3KHz deviation for 12.5KHz channel spacing. If CTCSS is used, subtract further the nominal CTCSS system deviation level.
5. Reduce the level from the audio oscillator to obtain a sinewave modulation, and then vary the modulation frequency around 50–500Hz and adjust the bin accel factor for an approximately flat response.

Note: Do not enter too low a value or the lock time and stability will be affected.

6. Return the audio level to +10dBm.
7. Set the modulation frequency to about 300Hz. Observe the demodulated clipped sinewave with drooping positive and negative deviation peaks. Increase the "ref level" to reduce the degree of drooping. Adjust so that a flat top is observed on the demodulation waveform. Check that if you vary the modulation frequency across a range of 50Hz–1KHz, the frequency response is flat. The peak deviation should still be the same as in step 4 above. If not, repeat steps 4 and 6.

Note: The modulation flatness will rise around 2KHz if the S Series is fitted with Butterworth- or Chebychev-type filters for the main limiter post LPF as used in the EIA-603 Build because of the group delay distortion of the filters. For a flatter response, ensure the standard Bessel filter is fitted.

8. Set the transmitter carrier center frequency by adjusting the Ref Bias level if necessary. Repeat step 6 because there is some interaction from the reference oscillator due to nonlinearity. Repeat as necessary.
9. Save as defaults.
10. Return the jumpers as before in step 2. Adjust the TX compress level RV2 for the standard system deviation level—usually 3KHz for 25KHz channel spacing and 1.5KHz for 12.5KHz spacing.
11. Set the VF level to the standard input level (–10dBm), and adjust the compress TX VF gain to just compress.
12. Go to the Channel Info screen and click on the channel number to be allocated to the calibration results. Click on Get Defaults, then OK.

13. Go to the next channel and load defaults. Key in the appropriate RF frequencies, and set the VCO level for the same deviation as in step 9. Repeat this step for all the channels required.

Note: A small error will result in the calibration of the ref level as in step 6 if the next channel frequency varies greatly from the original cal frequency. Recalibrate the ref level if necessary.

Caution: Due the high degree of adjustment available in the S Series, check the PLL stability by monitoring the PLL tune voltage with a CRO (Cathode Ray Oscilloscope) at the onset of PTT for minimal ringing.

Description of Program Functions

Synthesizer Control

The S Series Base Station has the facility for precise software control of the PLL characteristics. This provides the user with additional flexibility and capability for specialized or precise settings. The following program functions allow for control of the fractional-N synthesizer and are described as such:

PLL Correction Factor: Controls the relative amount of charge current into the PLL charge–pump circuit. The value for the PLL correction factor is loaded into the receiver and exciter synthesizer during normal operation. It is primarily used to control the dynamic PLL settling characteristics. A value of 0 will provide a minimum current and hence a slow and under-damped loop response. A value of 255 will provide the maximum current and hence a fast and over-damped loop response.

Bin Accel Main: Same as PLL correction factor except that the value for the bin accel main is only loaded into the exciter synthesizer during the transmitter modulation period. It is primarily used to control the static PLL characteristics. This will allow adjustment for a maximally flat modulation response near the cutoff frequency of the PLL. A value of 0 will provide a minimum current and hence an under-damped response. A value of 255 will provide the maximum current and hence an over-damped response.

Modulo: A modulo value of eight sets the synthesizer comparison frequency to eight times that of the channel spacing (synthesizer step size). A value of five is five times, respectively.

Channel Spacing: (Also referred to as the synthesizer step) As a rule, the oscillator frequency must be integer divisible by the modulo value and then the step size. The step size is usually set to half that of the channel spacing.

Accel Proportion: Controls the degree of speed up at the onset of PTT.

Accel Integral: Controls the multiplication factor of the accel proportion.

For further information, refer to the *Philips Semiconductor Data Book* for the SA7025DK chip.

Modulation Control

DC–FM uses two-point modulation, and its parameters can be set by the following:

VCO Deviation: The digital pot value sets the modulation level fed to the VCO modulation input. A value of 0 sets the minimum deviation level. A value of 255 sets the maximum deviation level.

Reference Bias: The digital pot value sets the center carrier frequency of the transmitter frequency. A value of 0 sets the highest carrier frequency. A value of 255 sets the lowest carrier frequency. A value

around 128 is normally used. If the value is too high or too low, unsymmetrical modulation distortion could result due to the limited range of the master reference oscillator.

Reference Level: The digital pot value sets the modulation level fed to the master reference oscillator. A value of 0 sets the minimum deviation level. A value of 255 sets the maximum deviation level. It primarily is used to set the modulation balance at low frequencies.

Transmit RF Power Output

Transmit Power: The digital pot value sets the RF drive level to the power amplifier. A value of 0 sets the transmitter power to minimum. A value of 255 sets the transmitter power to maximum.

CTCSS Control

TX Subtone: Directly enters the frequency of the transmitter modulation encoder.
Rx Subtone: Directly enters the frequency for the receiver decoder to operate.
TX Subtone Level: Controls the level of the transmitter modulation encoder. Steps are 0.85dB.

Channel Selection

Three methods are available for channel selection:

1. Software Channel Select via Utility Program: Ensure that channel 0 is selected on the DIP switch DIP1 located on the micro-controller board (all eight switches in the OFF position). Enter the channel number in the software select channel window on the Channel Info screen, and press **SELECT**.
2. Software Channel Select via Serial Command: Ensure that channel 0 is selected on the DIP switch DIP1 located on the micro-controller board (all eight switches in the OFF position). Send the string "chansXXX" where XXX = a three-digit number for the channel number. For example, to select channel 5, send the string "chans005." Baud rate is 9600 BPS.
3. Hardware Channel Select: Select the fixed channel for the S Series by using the DIP switch DIP1 located on the micro-controller board. Channel 1–255 is available in binary selection. Switch position 1 is channel 1, position 2 is channel 2, position 3 is channel 4, position 4 is channel 8, position 5 is channel 16, position 6 is channel 32, position 7 is channel 64, and position 8 is channel 128. For further details of all possible channels, see Appendix C.

Troubleshooting

The most common causes of problems are listed below:

Incorrect parameters set in the S Series utility program such as

1. wrong reference frequency oscillator value,
2. PLL correction factor or bin accel value too low,
3. accel values extreme,
4. channel spacing value not correct, or
5. frequency value not a multiple of the channel spacing / step size.

Other problems may include jumpers or DIP switches in wrong positions.

Glossary

3RD OIP	Third Order Intercept Point
AUX	Auxiliary
BPF	Band Pass Filter
BW	Bandwidth
CMOS	Complementary Metal Oxide Silicon
CRO	Cathode Ray Oscilloscope
CTCSS	Continuous Tone Coded Squelch System
DC	Direct Current
DIP	Dual Inline Package
EMI	Electro Magnetic Interference
FSK	Frequency Shift Keying
HPF	High Pass Filter
IC	Integrated Circuit
IF	Intermediate Frequency
I/O	Input / Output
JMP	Jumper
LC tank circuit	Resonant circuit consisting of an Inductor and Capacitor network
LED	Light Emitting Diode
LPF	Low Pass Filter
MMIC	Microwave Monolithic Integrated Circuit
Mobitex	Radio messaging system
MTBF	Mean Time Between Failure
NF	Noise Figure
PA	Power Amplifier
Pad	Circuit board land
PCB	Printed Circuit Board
PLL	Phase Locked Loop
PPM (ppm)	Parts Per Million
PTT	Push To Talk
POCSAG	Post Office Code Standardization Advisory Group
RAM	Random Access Memory
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
RU	Rack Unit
Rx	Receiver
Simplex	Single operation of either Transmitter or Receiver
S/N	Signal to Noise Ratio
Squelch	Muted audio signal
SW	Switch
TEMP	Temperature
TRM	Turn Around Mixer
TX	Transmitter
UHF	Ultra High Frequency
VCO	Voltage Controlled Oscillator
VC-TXCO	Voltage Controlled Temperature Compensated Crystal Oscillator
VF	Voice Frequency
VHF	Very High Frequency
VSWR	Voltage Standing Wave Ratio

Appendix A Specifications

Minimum Performance Specification

Minimum performance to exceed the following for 66MHz–960MHz:

ETS 300 086 Jan 1991
FCC Part 90
TIA/EIA-603
BAPT 225 ZV 1/2098 (German Softkeying)
CEPT T/R 24-01 E Sept 1988
EC Marking, EC EMC Directive 89/336/EEC
ETS 300 113
MIL-STD-810E
RFS32
TIA/EIA-603

General Specifications

S Series Rack Size:	19-in 2RU Case, 13-in (360mm) deep inc fan
S Series Overall Physical Size	3.5-in (89mm) high, 13-in (360mm) deep, 19-in (483mm) wide
Weight	19.8-lbs (9kg)
Supply Voltage:	13.8V +/– 20%
Power Consumption:	<600 mA receive, typical 440 mA
	<11A for 50W TX RF
Operating Temperature:	–10 to +60 C. –30 to +60 C option
Individual Module Dimensions:	Rx & TX W=100, L=180, H = 30mm
	PA W=78, L=300, H = 60mm
Standard LED indicators:	Power, Rx, TX, CTCSS, Aux, Alarm
Frequency Range:	Coverage 66–960 MHz
Synthesis Method:	Non mixing PL
	Fractional N synthesizer
Modulation:	Direct FM, +/–5 KHz
	+/–2.5 KHz narrow band
Channel Spacing:	30 KHz, 25 KHz, or 12.5 KHz
Synthesizer Step Size:	30, 25, 12.5, 7.5, or 6.25KHz
Channels:	256 Software or switch selectable
	1–99 BCD parallel selection
Frequency Range:	Coverage 66–960 MHz

Other frequencies or band allocations available.
Contact Spectra Engineering for details.

Band A	66–80 MHz
Band B	74–88 MHz
Band C	135–160 MHz
Band D	155–180 MHz
Band E	175–200 MHz
Band F	195–225 MHz
Band G	220–250 MHz
Band H	245–275 MHz
Band I	270–300 MHz
Band J	295–325 MHz
Band K	320–350 MHz
Band L	345–375 MHz
Band M	370–400 MHz
Band N	395–430 MHz
Band O	425–460 MHz
Band P	455–490 MHz
Band Q	485–520 MHz
Band R	805–825 MHz
Band S	824–849 MHz
Band T	850–870 MHz
Band U	872–905 MHz
Band V	890–915 MHz
Band W	917–950 MHz
Band X	925–960 MHz

Transmitter Module Specifications

RF Power Output:	5W to 50W (66-520 MHz) 5W to 35W, 50W optional for 13.8V/28V rail(800-960 MHz) 100W on special request
Frequency Stability:	2.5PPM, 1.5PPM or 1.0PPM
Audio Response:	Flat within +/- 0.5dB across BW Bessel LPF for data or Chebychev LPF
Audio Bandwidth:	DC(J-X Band) to 3400Hz base band (-0.5dB) 300Hz to 3000Hz for EIA-603 300Hz to 3400Hz nominal.
Modulation Distortion:	Less than 2% C-weighted.
S/N Ratio:	Better than 50dB, wide band. Better than 44dB, narrow Band.
Spurious:	Better than -90dBc.
RF Switching Bandwidth:	Same as band allocation.
RF Switching Bandwidth PA:	10MHz nominal, full band useable.
Duty Cycle:	100% for 50W RF output with Thermal controlled fan.
RF Rise Time:	4mS with continuous VCO selected (Controlled RF envelope).

Receiver Module Specifications

Sensitivity:	Better than –117dBm for 12dB (25 KHz spacing), C-weighted, De-emphasis. Typical –120dBm
Selectivity 66-520MHz (Option):	More than 80 dB for 25 KHz adj channel, more than 70 dB for 12.5 KHz adj channel, for switching BW 10MHz minimum
Selectivity 66-520MHz:	More than 75 dB for 25 KHz adj channel, more than 65 dB for 12.5 KHz adj channel, for switching BW same as band allocation
Selectivity 805-960MHz:	More than 70 dB for 25 KHz adj channel more than 65 dB for 12.5 KHz adj channel for switching BW same as band allocation
Spurious Resp:	Better than 90dB
Intermodulation:	Better than 80dB
Blocking:	Better than 100dB at +/–1MHz point
Distortion:	Less than 2%
S/N Ratio:	Better than 50dB C-weighted, wide band. Better than 44dB C-weighted, narrow band
RF Switching Bandwidth:	10MHz minimum or equal to band allocation
Receiver Front End BW:	Equal to band allocation, no retuning
Audio Bandwidth:	DC to 3400Hz (–0.5dB)
Squelch Opening Time:	20mS
Squelch Closing Time:	100mS
Conducted Spurious:	Less than -57dBm, typ –90dBm

Ancillaries

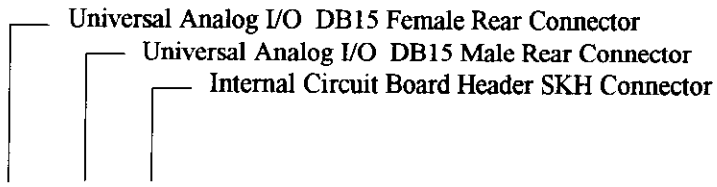
TX Timer:	2 minutes, on/off selectable
VF Level to Line:	+6 to –15dBm, 600 ohms unbalanced or differential
VF Level from Line:	+6 to –15dBm, 600 ohms unbalanced
Pre-Emphasis Accuracy:	Within +/–0.5dB of 6dB per octave curve
De-Emphasis Accuracy:	Within +/–0.5dB of 6dB per octave curve
VF Compressor Range:	>30dB for line input,
Control Outputs:	1K ohm 5V source/sink available
Alarm Output:	Open collector
PTT Input:	Logic or opto-isolated +/–5 to 48V
Channel Select:	8-way dip switch or RS232 or BCD
Repeater Tail Timer:	2 seconds nominal

Appendix B Interface Connections

S Series Rear Chassis Connector Description

Universal DB15 Analog I/O

Pin Number And Description:



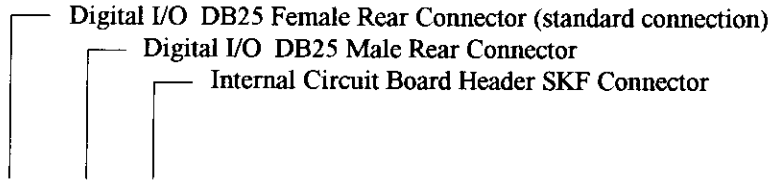
8	1	1	**EARTH** Use this earth for general connection and PTT return. For analog earth and audio common, use the Analog Earth pin.
15	9	2	**RECEIVER AUDIO 600Ω** Normal receiver audio output from op-amp. Nominal line level is set to –10dBm. Common return to analog earth or differential audio output pin.
7	2	3	**RECEIVER AUDIO 5Ω** Low-impedance differential audio output from op-amp.
14	10	4	**RX MUTE / SQUELCH MONITOR** The mute status can be monitored by reading this voltage. 5-volt logic high = signal received or the mute is open. Output impedance = 100KΩ . Connect to high input impedance (>1MΩ).
6	3	5	**O/C ALARM OUTPUT** The open collector output sinks current to earth when an alarm condition occurs. Same function as front panel alarm LED. An alarm is generated if the power amplifier is over temperature or if the supply voltage exceeds the defined limits. The trip points are selectable via the utility program.
13	11	6	**TX DC-FM INPUT** Wide band audio or data can be connected to this point. To conform to transmitter bandwidth emissions limits, this input is hard limited to the nominal deviation and Bessel filtered –3dB @ 3400Hz for minimum group delay. Input impedance is 100KΩ. If this input is not used, jumper # JMP14 on the micro-controller board should be removed to avoid any pickup of stray signals, or alternatively do not connect any wires to this pin. Also avoid the use of ribbon cables longer than 30–50cM because this can also result in excess coupling or crosstalk.
5	4	7	**TX REFLECTED POWER** The voltage from the reflected power directional coupler in the power amplifier goes directly to this pin. In a correctly terminated load, the voltage should be less than 200mV. Depending on the degree of mismatch at the load, the voltage will rise to approx 3–4 volts for 50 Watts forward power. The internal reflected power control circuit also monitors this point so that when the reflected power voltage exceeds half that of the forward power voltage, the forward power is then reduced to about 25% of full power. Full forward power is returned when the reflected power drops below the trip point mentioned. The output impedance is about 5KΩ.
12	12	8	**TX PTT IN** The standard PTT input is normally active low and can be driven from standard

			logic outputs or open collector. JMP9 should be in and JMP8 in position 1–2. To change polarity or voltage input also see OPTO PTT IN. Removing JMP9 will input the PTT via the opto coupler.
4	5	9	**RX DISCRIMINATOR** The receiver discriminator audio output is buffered, unfiltered, and DC-coupled to this point. Output impedance is low.
11	13	10	**TX OPTO PTT IN** This input is used only if a floating or opto input PTT is required. JMP9 **MUST** be removed. Positive or negative keying voltage can be applied to the input due to full wave rectifier and opto circuit. For a fully floating differential input voltage (+/–5 to +/–48 VDC), set jumper JMP8 in position 1–2. Putting JMP8 in position 2–3 will connect this point to earth.
3	6	11	**TX FORWARD POWER** The voltage from the forward power directional coupler in the power amplifier goes directly to this pin. In a correctly terminated load, the voltage should be about 3–4 Volts for 50 Watts. The output impedance is about 5KΩ. The internal forward power control circuit also monitors this point.
10	14	12	**ANALOG EARTH** General analog earth common for VF input and output.
2	7	13	**TEMPERATURE OUTPUT** The temperature output voltage is proportional to the temperature on the power amplifier heatsink.
9	15	14	**TRANSMIT AUDIO INPUT 600Ω** Transmitter audio input to op-amps etc. Nominal line input level is –10dBm. Can handle levels to greater than +10dBm. Common return to analog Earth.
1	8	15	**RX RSSI OUTPUT** The receiver's received signal strength indicator voltage is proportional to the log of the signal level at the antenna input. Voltage range is 0–5 volts. Output impedance is low. Dynamic range > 60dB.
NC	NC	16	**WIDE BAND TX MODULATION INPUT** Wide band audio or data may be connected to this point. **WARNING:** To conform to transmitter bandwidth emissions limits, the signal **MUST** be pre-filtered. Failure to do this WILL result in noncompliance of the TX emission spectrum. This input is not normally used except in special cases.

DB25 Digital I/O Connector

Each CMOS logic input is protected by a 10K Ohm series resistor to the input of the logic chip. There is also a 10K Ohm pull down resistor at each input so as to default the input value to zero.
Each logic output is protected by a 1K Ohm series resistor from the output of the logic chip.

Pin Number and Description:



13	1	1	**DIGITAL GROUND**
25	14	2	**INPUT PORT A** Spare 8-bit Logic Input bit 0
12	2	3	**INPUT PORT A** Spare 8-bit Logic Input bit 1
24	15	4	**INPUT PORT A** Spare 8-bit Logic Input bit 2
11	3	5	**INPUT PORT A** Spare 8-bit Logic Input bit 3
23	16	6	**INPUT PORT A** Spare 8-bit Logic Input bit 4
10	4	7	**INPUT PORT A** Spare 8-bit Logic Input bit 5
22	17	8	**INPUT PORT A** Spare 8-bit Logic Input bit 6
9	5	9	**INPUT PORT A** Spare 8-bit Logic Input bit 7
21	18	10	**INPUT PORT B** BCD Channel Select Units bit 0
8	6	11	**INPUT PORT B** BCD Channel Select Units bit 1
20	19	12	**INPUT PORT B** BCD Channel Select Units bit 2
7	7	13	**INPUT PORT B** BCD Channel Select Units bit 3
19	20	14	**INPUT PORT B** BCD Channel Select Tens bit 0
6	8	15	**INPUT PORT B** BCD Channel Select Tens bit 1
18	21	16	**INPUT PORT B** BCD Channel Select Tens bit 2
5	9	17	**INPUT PORT B** BCD Channel Select Tens bit 3
17	22	18	**OUTPUT PORT C** Spare 8-bit Logic Output bit 0
4	10	19	**OUTPUT PORT C** Spare 8-bit Logic Output bit 1
16	23	20	**OUTPUT PORT C** Spare 8-bit Logic Output bit 2
3	11	21	**OUTPUT PORT C** Spare 8-bit Logic Output bit 3
15	24	22	**OUTPUT PORT C** Spare 8-bit Logic Output bit 4
2	12	23	**OUTPUT PORT C** Spare 8-bit Logic Output bit 5
14	25	24	**OUTPUT PORT C** Spare 8-bit Logic Output bit 6
1	13	25	**OUTPUT PORT C** Spare 8-bit Logic Output bit 7
NC	NC	26	**NOT CONNECTED**

PC Serial Port-to-Radio Cable

Signal Name	DB9 PIN#	
TD	Transmitted Data	2
RD	Received Data	3
SG	Signal Ground	5

For additional information, see the Testing section of this manual.

Appendix C DIP Switch Settings

DIP Switch 1 Channel Selection

Three methods are available for channel selection (see the S Series Base Station Utility section of this manual):

Software Channel Select via Utility Program: Ensure that channel 0 is selected on the DIP switch DIP1 located on the micro-controller board (all eight switches in the OFF position). Enter the channel number in the Software Select Channel window on the Channel Info screen and press Select.

Software Channel Select via Serial Command: Ensure that channel 0 is selected on the DIP switch DIP1 located on the micro-controller board (all eight switches in the OFF position). Send the string "chansXXX" where XXX = a three-digit number for the channel number. For example, to select channel 5, send the string "chans005." Baud rate is 9600 BPS.

Hardware Channel Select: Select the fixed channel for the S Series by using the DIP switch DIP1 located on the micro-controller board. Channel 1–255 is available in binary selection. Switch position 1 is channel 1, position 2 is channel 2, position 3 is channel 4, position 4 is channel 8, position 5 is channel 16, position 6 is channel 32, position 7 is channel 64, and position 8 is channel 128.

A table of DIP switch 1 settings follows, where a switch ON is indicated by an "x" in a cell and no entry in a cell represents a switch OFF.

Channel	SW 1	SW2	SW3	SW4	SW5	SW6	SW7	SW8
0								
1	x							
2		x						
3	x	x						
4			x					
5	x		x					
6		x	x					
7	x	x	x					
8				x				
9	x			x				
10		x		x				
11	x	x		x				
12			x	x				
13	x		x	x				
14		x	x	x				
15	x	x	x	x				
16					x			
17	x				x			
18		x			x			
19	x	x			x			
20			x		x			
21	x		x		x			
22		x	x		x			
23	x	x	x		x			
24				x	x			
25	x			x	x			

26		x		x	x			
27	x	x		x	x			
28			x	x	x			
29	x		x	x	x			
30		x	x	x	x			
31	x	x	x	x	x			
32						x		
33	x					x		
34		x				x		
35	x	x				x		
36			x			x		
37	x		x			x		
38		x	x			x		
39	x	x	x			x		
40				x		x		
41	x			x		x		
42		x		x		x		
43	x	x		x		x		
44			x	x		x		
45	x		x	x		x		
46		x	x	x		x		
47	x	x	x	x		x		
48					x	x		
49	x				x	x		
50		x			x	x		
51	x	x			x	x		
52			x		x	x		
53	x		x		x	x		
54		x	x		x	x		
55	x	x	x		x	x		
56				x	x	x		
57	x			x	x	x		
58		x		x	x	x		
59	x	x		x	x	x		
60			x	x	x	x		
61	x		x	x	x	x		
62		x	x	x	x	x		
63	x	x	x	x	x	x		
64							x	
65	x						x	
66		x					x	
67	x	x					x	
68			x				x	
69	x		x				x	
70		x	x				x	
71	x	x	x				x	
72				x			x	
73	x			x			x	
74		x		x			x	
75	x	x		x			x	
76			x	x			x	
77	x		x	x			x	
78		x	x	x			x	

79	x	x	x	x			x	
80					x		x	
81	x				x		x	
82		x			x		x	
83	x	x			x		x	
84			x		x		x	
85	x		x		x		x	
86		x	x		x		x	
87	x	x	x		x		x	
88				x	x		x	
89	x			x	x		x	
90		x		x	x		x	
91	x	x		x	x		x	
92			x	x	x		x	
93	x		x	x	x		x	
94		x	x	x	x		x	
95	x	x	x	x	x		x	
96						x	x	
97	x					x	x	
98		x				x	x	
99	x	x				x	x	
100			x			x	x	
101	x		x			x	x	
102		x	x			x	x	
103	x	x	x			x	x	
104				x		x	x	
105	x			x		x	x	
106		x		x		x	x	
107	x	x		x		x	x	
108			x	x		x	x	
109	x		x	x		x	x	
110		x	x	x		x	x	
111	x	x	x	x		x	x	
112					x	x	x	
113	x				x	x	x	
114		x			x	x	x	
115	x	x			x	x	x	
116			x		x	x	x	
117	x		x		x	x	x	
118		x	x		x	x	x	
119	x	x	x		x	x	x	
120				x	x	x	x	
121	x			x	x	x	x	
122		x		x	x	x	x	
123	x	x		x	x	x	x	
124			x	x	x	x	x	
125	x		x	x	x	x	x	
126		x	x	x	x	x	x	
127	x	x	x	x	x	x	x	
128								x
129	x							x
130		x						x
131	x	x						x

132			x					x
133	x		x					x
134		x	x					x
135	x	x	x					x
136				x				x
137	x			x				x
138		x		x				x
139	x	x		x				x
140			x	x				x
141	x		x	x				x
142		x	x	x				x
143	x	x	x	x				x
144					x			x
145	x				x			x
146		x			x			x
147	x	x			x			x
148			x		x			x
149	x		x		x			x
150		x	x		x			x
151	x	x	x		x			x
152				x	x			x
153	x			x	x			x
154		x		x	x			x
155	x	x		x	x			x
156			x	x	x			x
157	x		x	x	x			x
158		x	x	x	x			x
159	x	x	x	x	x			x
160						x		x
161	x					x		x
162		x				x		x
163	x	x				x		x
164			x			x		x
165	x		x			x		x
166		x	x			x		x
167	x	x	x			x		x
168				x		x		x
169	x			x		x		x
170		x		x		x		x
171	x	x		x		x		x
172			x	x		x		x
173	x		x	x		x		x
174		x	x	x		x		x
175	x	x	x	x		x		x
176					x	x		x
177	x				x	x		x
178		x			x	x		x
179	x	x			x	x		x
180			x		x	x		x
181	x		x		x	x		x
182		x	x		x	x		x
183	x	x	x		x	x		x
184				x	x	x		x

185	x			x	x	x		x
186		x		x	x	x		x
187	x	x		x	x	x		x
188			x	x	x	x		x
189	x		x	x	x	x		x
190		x	x	x	x	x		x
191	x	x	x	x	x	x		x
192							x	x
193	x						x	x
194		x					x	x
195	x	x					x	x
196			x				x	x
197	x		x				x	x
198		x	x				x	x
199	x	x	x				x	x
200				x			x	x
201	x			x			x	x
202		x		x			x	x
203	x	x		x			x	x
204			x	x			x	x
205	x		x	x			x	x
206		x	x	x			x	x
207	x	x	x	x			x	x
208					x		x	x
209	x				x		x	x
210		x			x		x	x
211	x	x			x		x	x
212			x		x		x	x
213	x		x		x		x	x
214		x	x		x		x	x
215	x	x	x		x		x	x
216				x	x		x	x
217	x			x	x		x	x
218		x		x	x		x	x
219	x	x		x	x		x	x
220			x	x	x		x	x
221	x		x	x	x		x	x
222		x	x	x	x		x	x
223	x	x	x	x	x		x	x
224						x	x	x
225	x					x	x	x
226		x				x	x	x
227	x	x				x	x	x
228			x			x	x	x
229	x		x			x	x	x
230		x	x			x	x	x
231	x	x	x			x	x	x
232				x		x	x	x
233	x			x		x	x	x
234		x		x		x	x	x
235	x	x		x		x	x	x
236			x	x		x	x	x
237	x		x	x		x	x	x

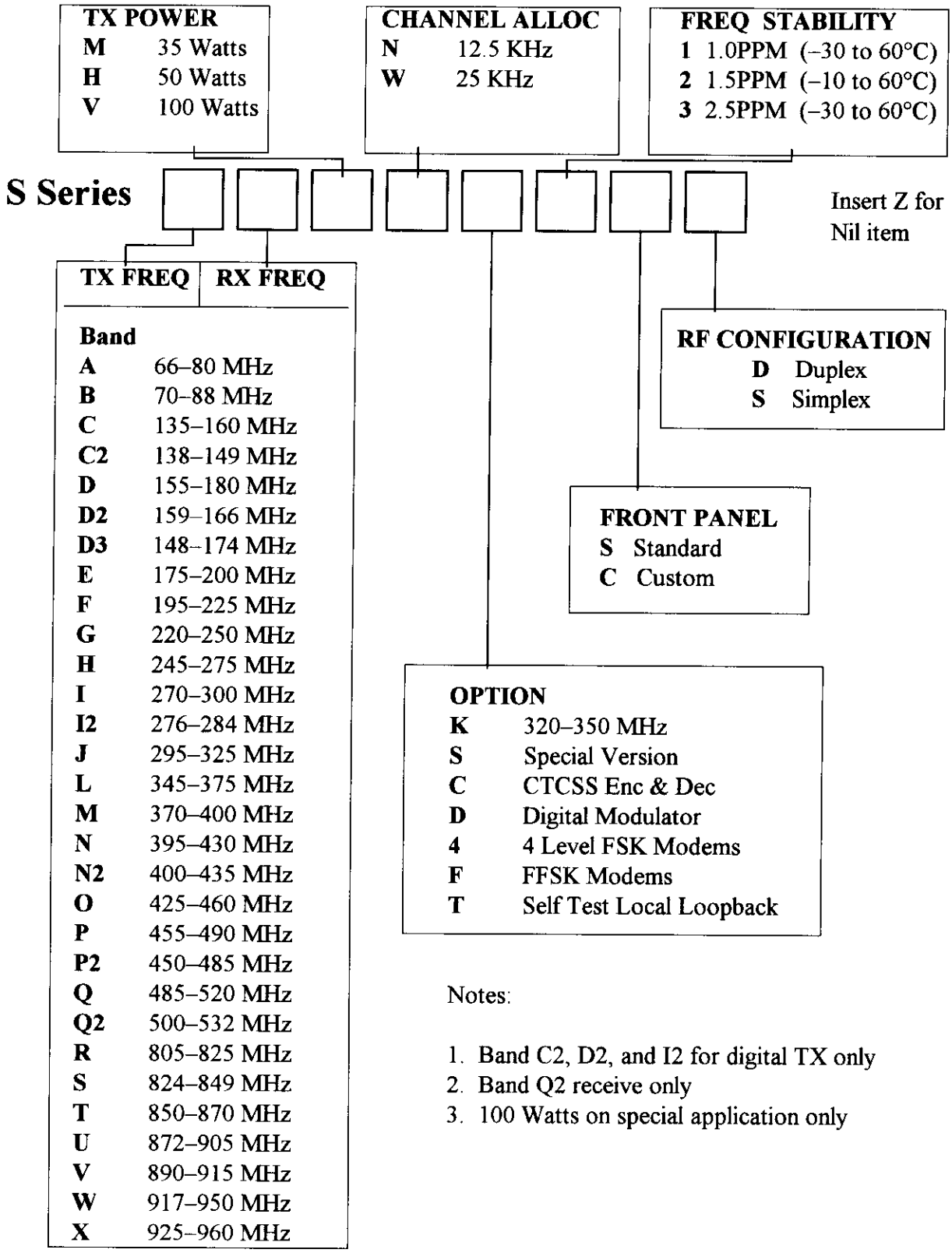
238		x	x	x		x	x	x
239	x	x	x	x		x	x	x
240					x	x	x	x
241	x				x	x	x	x
242		x			x	x	x	x
243	x	x			x	x	x	x
244			x		x	x	x	x
245	x		x		x	x	x	x
246		x	x		x	x	x	x
247	x	x	x		x	x	x	x
248				x	x	x	x	x
249	x			x	x	x	x	x
250		x		x	x	x	x	x
251	x	x		x	x	x	x	x
252			x	x	x	x	x	x
253	x		x	x	x	x	x	x
254		x	x	x	x	x	x	x
255	x	x	x	x	x	x	x	x

DIP Switch 2 User Function Select

Switch Number	Description
Switch 1	**PTT Delay** Inserts a 100mS delay for the transmitter RF rise time. Must be selected when using a coaxial simplex changeover relay to prevent switching RF power.
Switch 2	**Simplex On** Selects simplex mode of operation.
Switch 3	**TX Timer On** Transmitter is disabled after 2 minutes continuous use.
Switch 4	**Repeater On** Selects automatic receiver-to-transmitter repeater function. The transmitter will also have a 2-second "hang time."
Switch 5	**TX VCO Cont** Enables the transmitter VCO to operate continuously in "hot standby" mode. This speeds up the transmitter rise time to 4mS. **Caution**: Low-level signal leakage can affect the performance of the receiver if the transmitter is on the same frequency.
Switch 6	**TX FSK** Generates an FSK test signal. Not normally used.

Appendix D Model # Configuration Guide

Rev 1.3 13 October 1997. Consult Spectra for availability details on specific configurations and options.



Notes:

1. Band C2, D2, and I2 for digital TX only
2. Band Q2 receive only
3. 100 Watts on special application only