

# SG-237 Smartuner™ HF Antenna Coupler

Includes SG-237 Porta, SG-237 PCB and QMS-37



August 2001



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SGC develops, manufactures, and sells high performance single sideband (SSB) communications equipment. Since 1971, the company has sold to the marine, military, aviation, and industrial markets worldwide. Over these years, SGC has earned an outstanding reputation for product reliability and for after sales service.

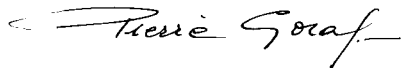
The company keeps pace with equipment options, engineering developments, and design requirements. Its products are the most competitive in the entire long distance communication market. SGC equipment is presently being used by the United Nations for inter-communications in developing countries throughout the world.

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SGC also supplies U.S. government agencies, several foreign governmental agencies, and major petroleum companies throughout Asia and Latin America.

All SGC equipment is designed and manufactured in the USA. SGC has qualified people ready to provide technical information, assistance in selecting equipment, and recommendations for any installation.

SGC welcomes your call to discuss your SSB requirements.



*Therie Graf*



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## Specifications - Subject to change without notice

HF Frequency Range:	1.8-60 MHz
Power Input Range:	3 to 100 watts (PEP) Or 40 watts max. on CW Or 100 watts for 4 second TX and 6 second RX
Number of channels:	Unlimited
Revolving memory bins:	168
Input Impedance Range:	45-55 ohms
VSWR: (Typical)	Typically less than 1.4:1
DC Input Requirement:	+13.8 VDC (nominal)
DC Operating Range:	+10 to 18.5 VDC
Input Current: Average:	300 milliamps
Random set time:	Typical: less than 2 seconds
Recurrent set time:	Typical: less than 10 milliseconds
Antenna Length:	Minimum length of 7 ft. - 3.5 to 60 MHz Minimum length of 23 ft.- 1.8 to 60 MHz
Installation:	Any position
Operating Temperature:	-35° to +70°C
Power Cable:	Shielded 4 conductor RG-58 coax with PL-259 connector
Power Cable Length:	9 feet in length
Antenna types:	1. Whip 2. Backstay (marine, sail) 3. Dipole centerfed 4. Dipole with feedline 5. Loop (small) 2x2 multi turn 6. Loop (large) 10 ft. and up single turn 7. Longwire 8. Ladder feed
Size:	SG-237 9"L x 7"W x 1.5"H (23cm x 18cm x 4cm) SG-237 Porta 7.25"L x 6"W x 3"H (18cm x 15cm x 8cm) SG-237 PCB 5.5"L x 6"W x 1"H (14cm x 15cm x 2cm)
Weight:	SG-237 2 pounds (1 kg) SG-237 Porta 4 pounds (2 kg) SG-237 PCB 1.25 pounds (6 kg)
SG-237 Case	ABS plastic on anodized aluminum base
SG-237 Porta Case	Extruded Aluminum
Porta Ground System:	Four radials of 12 feet each

This manual is produced as a guideline for the SG-237 antenna coupler. Performance and results may vary and SGC does not warrant any installation or any result. This manual is subject to change without notice.

## 1.0 SG-237 Supplied Items

- SG-237 Coupler
- Manual
- Cable RF/Control 9 foot long

## 2.0 Mechanical Design

The SG-237 is supplied in a weather proof case with mounting holes. RF and DC power is supplied to the unit through the same cable. The cable is a 9 foot 4 conductor (with coax for RF) cable with wires for ground, power, optional SmartLock controls, and optional LED indicator.

The SG-237 antenna coupler's weatherproof case is designed to withstand the environmental conditions encountered aboard ship when mounted on the weatherdecks. The internal construction is designed to withstand the shock and vibration of marine service. Corrosion-resistant hardware and passive alloys are employed throughout. We do not recommend opening the Smartuner case unless it is necessary. For 99% of installations, the factory settings for jumpers will be correct. The coupler must be installed in an area not directly exposed to the sunshine or rain. Should you have occasion to open the case, it must be re-sealed under low humidity (below 35%) and care used to ensure the gasket which seals the unit is placed properly to maintain watertight integrity of the unit. Although the Smartuner is built very solidly, it is good installation practice to provide additional protection from the elements. SGC makes the following recommendations:

### 2.1 Marine Mounting

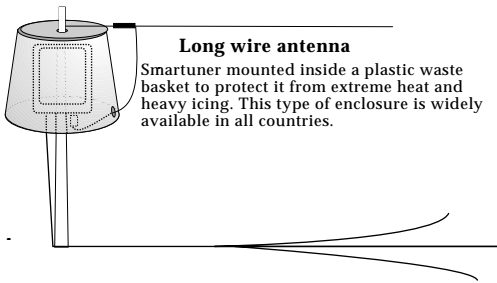
The Smartuner should be located inside the house or under the aft lazaret on a sailboat. On power boats, the coupler may be mounted outside, but an additional protective housing is recommended. The preferred installation if vertical is with the RF terminals pointing upward. The antenna connects to the screws on the top. The SG-237 may be mounted in any position including inverted without any degradation of performance.

## 2.2 Desert and High Temperature Installations

The Smartuner may be used in very hot climates on a continuous basis if some additional protection from direct sunlight is provided and if coupler is installed in a protected area. Temperatures inside a vehicle may exceed 212°F (100°C). It is desirable to keep the coupler in the shade if possible.

## 2.3 Additional Weather Protection Installations

To protect the unit from direct exposure to sunlight and to prevent heavy build up of ice, we recommend installing the Smartuner under protective housing. If you are mounting it on a tower in a hot or cold climate, a plastic wastebasket (such as those made by Rubbermaid™) makes an excellent weather cover and costs only a few dollars.



## 3.0 Coupler Configuration

Schematic Q30102700, sheet 4, page 29 is the schematic diagram of the two basic coupler networks. Note that the L network as viewed from the generator, may be configured as either “C in” or “C out,” whichever is required by the load. In either case, the end of the network containing the shunt C element will be the higher impedance end of the network.

### 3.1 Connections to SG-237

Drawing Q40105418, page 31 is the diagram of the antenna coupler connections. RF input and ground is applied to the PL259 connector on the end of the cable, +13.6 VDC is connected to the red wire - ground to the black wire, and an appropriate antenna and RF ground system are connected to the Antenna stud and the RF ground stud respectively. The TND line (white with black trace wire) can be connected to the

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transceiver or the SmartLock. This line cannot be connected to both units simultaneously.

## 3.2 Tuning Process

An array of detector devices in the SG-237 monitor the antenna system impedance, reactance signal, and the VSWR load when RF power is applied to the unit. The coupler also monitors forward power, since the control computer requires an indication of both forward and reflected power in order to allow tuning to proceed. The computer uses the forward power detector as a check to ensure that the measurements made are applied RF and are not spurious levels from the data conversion system. The SG-237 will proceed to tune only when enough forward power is present to confirm this check. After RF is applied to the detector system, it then passes through the coupler tuning array. The coupler tuning array consists of seven capacitors in shunt on the input arm of the network, eight inductors in the series arm, and four more capacitors in shunt on the output arm, all arranged in binary increments. Relays are provided in conjunction with each lumped constant and allow removal or entry as desired. A network having 128 values on input shunt C, 16 values of output shunt C, and up to 256 values of series L is possible with the manipulation of these 19 relays.

## 3.3 Impedance Detector

RF transformers T1 and T3 drive the impedance bridge that is balanced at 50 ohms. T3 samples the line current and thus D7 out-puts a negative DC level proportional to line current. A tertiary winding on transformer T1 provides a line voltage sample to D2 that provides a positive voltage proportional to line voltage. R18 and R11 act as a summing network for the current and voltage signals, with ratios chosen, such that at 50 ohms, the summed signals result in a balanced or zero voltage condition. If the line impedance goes to high, the signal from the voltage sensor will be relatively higher than the current sensor, which will result in a net positive output voltage from the summing network. Similarly, a low line impedance will result in more output from the current sensor, resulting in a net negative output voltage from the summing network. The summing network output is shifted to a 0 to 5v range, then fed to the processor's A to D converter port, and used within the micro-controller.

### 3.4 VSWR Detector

A directional coupler is made up of a current transformer T2 and a voltage transformer T1, in conjunction with termination resistors R35, R36 and R33, R34. The coupler is inserted in the 50-ohm transmission line between the input connector, ST2 RF - ST3 GND, and the tuning network. The forward power is measured across termination R33, R34 and reflected power is measured across termination R35, R36. Diode D1 generates a positive DC voltage proportional to forward power and D3 generates a positive DC voltage proportional to reflected power. The forward DC output is fed to a voltage divider consisting of R19 and R14. These voltages are input to the RF power detector and to an A to D converter port of the processor. The reflected DC output passes through a voltage divider consisting of R29 and R16, and then it also goes to an A to D converter port of the processor.

### 3.5 Phase Detector

A phase detector is formed by T3, A1, and their associated components. This detector indicates the state of any reactance associated with the antenna coupler as noted from the generator. A line current sample is compared in phase with a voltage sample in a double balanced mixer. Output polarity varies negative or positive depending on the reactance of the antenna. The output of phase detector A1 is shifted to a 0 to 5v range, then fed to processor's A to D converter port and used within micro controller.

### 3.6 Central Processing Unit (CPU)

A tune-up algorithm, which is contained in the memory of the micro-processor, implements the antenna matching. It is designed around the MC68HC711E9 CPU that features a versatile instruction set, RAM, and EEPROM (memory which is saved after the coupler is turned off). The antenna coupler relays are controlled by latches U6, U7, & U8 which receive serial data input directly from the CPU. During operation, data is transferred into the CPU from the A to D ports and Input Capture port (measures RF frequency). Basically, the program monitors the status of the input sensors and—starting from a preset condition—uses a built-in algorithm to achieve a tuned condition. When the tuning algorithm is complete, the CPU saves the settings in its EEPROM, which is addressed by the applied RF frequency. This non-

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volatile memory table is the basis of the exclusive learning feature of the SG-237. After it has stored and latched the network status, the CPU waits for RF to cease transmitting and returns to the Stop mode. When RF is re-transmitted, the first step in the tuning algorithm is to measure the frequency of the signal passing through the coupler. From the frequency data, the computer then searches its EEPROM for previously stored data. If data is found, it is tested for validity, and the required “end of tune” conditions will be sensed by the RF sensors. Then the data will be latched in place, and the CPU will again wait for RF to cease transmitting and turn to the Stop mode. This process takes about 10 milliseconds, which is the same length of time that is required to close the network relays.

### **3.7 Initialization**

The microcomputer is usually in the Stop mode and requires an interrupt signal (XIRQ) to start program implementation. The XIRQ is obtained from the RF detector circuitry. This line, going low, will wake the CPU from the Stop mode.

### **3.8 Jumper settings**

The SG-237 may be bypassed for broad band (un-tuned antenna) scanning listening in receive mode. All you need to do is press the reset button of the SmartLock (if installed) or turn power to the coupler off and on. When the coupler comes back on, the tuning elements remain out of the circuit until the Smartuner is activated by a transmitted signal. If broad band operation is required during receive for scan operation, jumper JP1 may be set to the Yes position. This will drop the tuning elements out of the circuit on receive only. Jumper JP1 is located adjacent to MCU (U5) along the edge of the printed circuit board. Setting JP1 to the Yes position is recommended if you are using a radio for split band communications, for scanning selective calling protocols, or for Automatic Link Establishment (ALE). The default is: Tuning Out In Rcv: [NO].

Jumper JP3 bypasses the coupler's memories. This means that each time the coupler is used on a different frequency, it will re-tune rather than use previously stored information. The default is: Tune From Memory: [YES].

## 4.0 Tuning Process and Options

MicroTune™ Software

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The SG-237 MicroTune™ Software is unique software which allows precise tuning of the digitally controlled  $\pi$  and L network to tune a wide variety of antennas. The versatile MicroTune™ software offers its user these special functions:

1. The coupler is activated whenever forward power is present.
2. In addition to sampling VSWR to determine if the coupler should re-tune, frequency comparison is employed. This causes the coupler to tune when ever the transmit frequency changes independent of the VSWR reading.
3. Extensive tuning paths are used to test different antenna situations. The initial tuning of a new frequency (or switched antenna) may require up to two seconds. Any further tuning is accomplished in a matter of milliseconds if jumper JP3 (Tune From Memory) is in its default position.
4. Facilities and algorithms are used which enable accurate tuning at the low end of the frequency band—even on shorter antennas than previously possible.
5. The BITE (Built-In-Test-Equipment) Indicator Tune LED includes a safety feature that alerts the operator to a mismatched condition, with blinking indicators, when proper tuning conditions have not been met. In this situation, the software will “time out” within 20 seconds unless a new frequency is sensed, which will cause an immediate time out, and the coupler will attempt to match the new frequency. The microprocessor of the coupler “wakes up” every time the coupler has forward power. However, re-tuning takes place only if the frequency has changed or the VSWR exceeds 2:1.

### 4.1 Program Description

When DC power is applied, the computer initializes the processor registers in accordance with the hardware. All tuning elements are then removed and the 'tune' indicators are turned off. At this time the computer reverts to a "sleep" mode awaiting RF power.

Detecting forward power. Once forward power is detected and the optional SmartLock is switched to Normal, the current coupler settings are sent to the relays. Next, the VSWR is checked and the frequency measured. If the


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VSWR is greater than 2:1 or a difference in frequency is detected, the program branches to the re-tune program. If it is determined that the VSWR is less than 2:1 and the frequency has not changed, the computer returns to the Stop mode. Re-tuning. Once it is determined that re-tuning is necessary, a test is made to see if JP3 is set to tune from memory. If the result is re-tuning from memory, settings are recalled from the EEPROM based on the frequency measured. The recalled data is then tested for validity. If the data proves invalid, it is bypassed and re-tuning is performed. If the data recalled proves valid, the data is sent to the relays and the VSWR is checked. If the VSWR is less than 2:1, the program branches to the “OK Tuned” section of the program. If the VSWR is found to be greater than 2:1, the program branches to the “re-tune” program.

Selecting tuning path. Several tests are made to determine which tuning algorithm or path should be used to tune the coupler. These tests are based on frequency, antenna input impedance, antenna phase, and VSWR. Numerous subroutines are executed repeatedly, depending on the status of the criteria mentioned above, in order to achieve proper tuning.

Signaling “no-tune.” Should the initial primary tuning sequence prove unsuccessful, secondary algorithms are attempted until all possible routines have been exhausted. If, after the secondary attempts, the coupler still cannot achieve a proper VSWR, the program branches to a “no-tune” program. Here, the LED's and remote tune indicator will blink on and off for about 15 seconds to tell the user a proper VSWR could not be found. After the indicators stop blinking, the program waits for forward power to cease (if it has not ceased already) and returns to stop mode. At this point the user should try several other frequencies. If the “no-tune” condition persists, check the installation of the antenna, coupler, radio, and ground system for possible problems.

Signaling “OK tune.” If the coupler achieves a good VSWR during the tuning sequence, the program branches to the “OK Tune” section of the code. Here, the tune indicators are engaged. A test is then made to check if JP3 is set to tune from memory. If so, the frequency is measured and the tuning elements used are saved in memory coupled with a verification code. Once saved, a test is made on JP1 to check if the

duplex mode has been selected. If so, the transmit tuning elements remain in circuit until the receive mode is verified. At this time, all tuning elements are removed. The frequency is then saved for future comparison and the CPU reverts back to the STOP mode.

## 4.2 Tuning Paths

As mentioned previously, various tests are executed to determine the most logical tuning sequence to be performed. Dependent on the test results, additional tests and appropriate sub-routines are executed throughout the tuning process. Following are examples of the activity that occurs when the coupler must be matched to a frequency that requires a slightly longer or shorter antenna:

### 4.2.1 Antenna Too Short

Once coupler has verified RF power, tuning sequence proceeds as follows:

1. Series inductance is added until the phase is deemed as being inductive. At this point it is normal for the input impedance to be low.
2. Input capacitance is added until the antenna is no longer inductive.
3. The program will continue to increment the series inductance in .125  $\mu\text{H}$  steps—each time normalizing the input impedance with input capacitance until a low VSWR is measured of less than 2:1. This process will continue until the VSWR has climbed back to higher than 2:1 or the impedance has become high.
4. The settings that gave the lowest VSWR have been kept in memory and are now recalled to verify it is a low VSWR
5. At this point the tune indicators are engaged. The current relay data is saved if JP3 is set to tune from memory; if JP1 is set to tune elements out during receive position, the program waits until forward power is no longer present, then removes all tuning elements. The frequency is saved for future frequency comparison, and the computer reverts to Stop mode.

### 4.2.2 Antenna Too Long

Once the coupler has verified RF power, the tuning sequence proceeds as follows:

1. Output capacitance is added until the phase switches to capacitive.
2. At this point, series inductance is added until the antenna is no

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longer capacitive.

3. Fine tuning is performed by trying a small amount of input capacitance (this may or may not be required).

4. At this point, the program acts the same as step 5 in section 4.2.1. The preceding gives a simplified program flow on only two possible antenna conditions. Much more complex tuning is normally the case. Further detailed description is beyond the scope of this manual.

### **4.2.3 JP1—Tuning Elements Out During Receive**

(Factory Default Setting: No)

**YES** - In this position the software will retain data required in transmit to match the coupler while removing all tuning elements when no forward power is detected.

**NO** - In this position, coupler will retain the required tuning data and will change nothing whether in receive or transmit. If typical operation is out of band duplex, **Yes** would be most likely to give better performance. If in band, operation is typical and duplex or simplex is the predominant mode of operation, then **No** is usually the better choice.

### **4.2.4 JP3—Tune From Memory**

(Factory Default Setting: Yes)

**YES** - In this position the coupler will recall data previously saved and try this data before attempting to re-tune. If the data is valid and the VSWR is less than 2:1 the tune is completed. In this position the coupler will save any new data in its memory for any frequency. A new frequency must first be learned, while in this mode, before it can be recalled.

**NO** - In this position, the coupler will not use previously saved tuning data. Each time a different frequency is selected, the coupler will proceed through a complete tuning sequence. Clearly, the advantage of **Yes** is speed. The coupler will seem to be matched instantly when in this position, if the frequency being used has previously been saved in EEPROM. Disadvantages include a difference in frequency too small for the computer to detect. This would result in recall of valid data that may not necessarily present the best match. We suggest starting with JP3 in the **Yes** position. If operation is as expected, don't change it.

## 5.0 Coaxial Output Application

SGC always recommends placing the antenna coupler as close as possible to the base of the antenna - regardless of whether it is an SGC coupler or another brand. All SGC couplers can be operated with a coaxial cable output connection; but this is not our recommendation. Antenna “tuners” which use coaxial cable connections are actually trimmer tuners and have a limited adjustment range (25 to 800 ohms). This impedance limitation prevents high voltages and current which may cause flashing or burning of the coaxial cable. Keep in mind that this limitation is created by the coaxial cable - not the coupler. Trimmer tuners are less expensive than antenna couplers and much more common. However, because of their impedance range limitation, they cannot tune whip or end fed wire antennas. On the other hand, SGC antenna couplers are not limited in their impedance ranges and will tune all types of antennas, including end fed wire and whips.

## 6.0 B.I.T.E.\* Status LED Descriptions

\*Built In Test Equipment

### TND

This LED will light when the tuner has found an acceptable match. It will remain lit until conditions have changed which will cause the tuner to find a different match. (i.e. A new transmit frequency has been detected, or tuner has been reset.)

### L'Z'

This LED shows the status of the antenna impedance. When lit, the impedance is 50 ohms or less. When off, the impedance is greater than 50 ohms.

### 2:1

This LED will light when the VSWR is greater than 2:1. It will extinguish when VSWR is less than 2:1.

### PHZ

This LED indicates the status of the antenna reactance. When lit, reactance is inductive. When off, reactance is capacitive.

### FWD

This LED indicates the presence or lack of RF power from the radio. When transmitting, the LED will light to indicate RF is being detected. In receive, the LED should be extinguished.

### OTHER

All LEDs will blink on and off at a rate of 2Hz to indicate the tuner was not able to find a valid match.

Note that these status LEDs are usually used to aid a technician in diagnosing the status of the antenna system and should not be thought of as laboratory instruments.

As the Smartuner tunes, the BITE status will be continually updated from the CPU.

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## 7.0 Optional Smartlock

The SmartLock allows the operator to have additional control over the SG-237. It is not required for normal operation of the coupler.

### 7.1 Tune, Tune Lock/Reset

Tuned (green LED)

Turns on when the coupler has successfully tuned.

Normal/Tune Lock

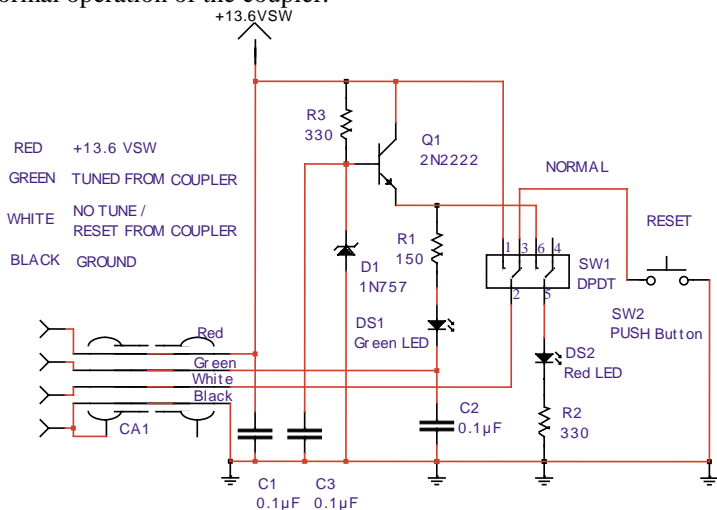
Toggle switch which allows user to prevent coupler re-tuning by switching to the Tune Lock position. When in the Tune Lock position, the red LED blinks to notify the user that the coupler is locked on the current setting.

Reset

Pushing the red reset button allows the coupler to be reset, if the toggle switch is in the normal position. This is preferred over turning the input power off and on.

### 7.2 SmartLock Notes

The Tune Lock function is in most cases unneeded. Inadvertent re-tuning is a rare occurrence. Re-tuning may occur when the environment or antenna system has changed. In this case, re-tuning is within normal operation of the coupler.



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## 8.0 Do-It-Yourself Light-Bulb Dummy Load

Any time that a transmitter is used, it must be outputting into a load. A load is anything that the output power can be pumped into. If the transmitter is operated without any sort of load connected, the final amplifier stage could become severely damaged. The problem is that you should never test a transmitter on the air for the first time, if you are unsure about how to operate it, and if you are unsure whether it is working properly. You could create harmful interference to other stations.

To test transmitters without actually operating into an antenna, dummy loads were created. A dummy load is a load that will dissipate the energy from the transmitter instead of emanating it into the ionosphere. Nearly all commercial dummy loads are large oil-filled cans. These dummy loads change the transmitted energy into heat, which is absorbed by the oil. Because different transmitters output different amounts of power, different sizes of dummy loads must be used. Dummy loads for typical amateur powers (<500 watts) are relatively inexpensive and are readily available.

Unfortunately, when you use a can-type dummy load, you can't see "what's happening" with your transmitter. In this case, you can use a light-bulb dummy load to test your transmitter. Here, the light bulb is directly connected to the output of the transmitter and it dissipates the RF energy as light. The light bulb dummy load is more useful than the oil-can type because you can guess how much power is being output, you can see the voice modulate the SSB (the light will flicker with your voice peaks), and you can tune the transmitter for maximum output (if the transmitter is an older model that requires tuning).

Before building or using the light-bulb dummy load, remember that these models typically don't dissipate the transmitter's output as well as an oil-can dummy load. The result is that RF will "leak" out; we have heard a few stories of amateurs who were heard around town while operating their transmitters into a light-bulb dummy load. If you use this system, make sure that you test the equipment on a clear, harmless frequency. (NEVER test with the transmitter set on an emergency frequency.)

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SGC recommends that you build the light-bulb dummy load with the following parts (although we have made one with an old light fixture and a makeshift version with just alligator clip leads and a light bulb):

- \* AC socket to cable with a PL-259 connector (for transceiver)
- \* AC socket to cable with alligator clips (needed with coupler)
- \* Light bulb to AC adapter
- \* 75 to 125 watt light bulb, 120 to 220 VAC
- \* 100 watt radio transceiver
- \* Any SGC Smartuner or equivalent

## RADIO TEST PROCEDURE

1. Connect the transceiver light bulb load to the radio RF in/out jack.
2. Turn on the radio and set the CW mode.
3. Key the PTT switch on the microphone and look at the light bulb. If the light bulb load is connected and the radio is transmitting, the light should turn on.
4. Set the radio to SSB mode.
5. Key the PTT switch on the microphone and talk into the microphone. Notice that the light turns on when you talk.

## COUPLER TEST PROCEDURE

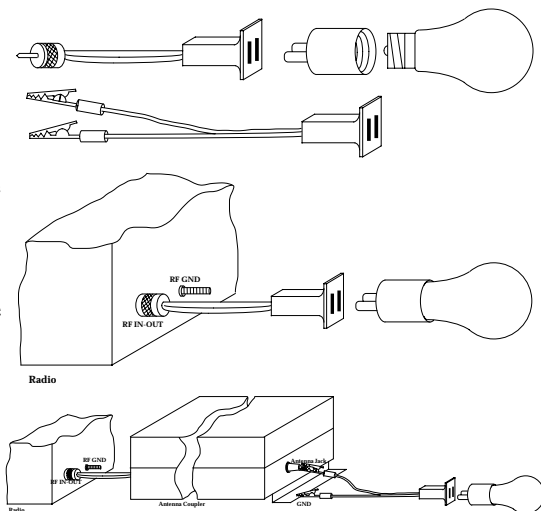
1. Connect the coupler to the radio.

2. Connect coupler light bulb load to Smartuner coupler antenna output.

3. Turn on radio and Smartuner coupler.

4. Set the radio to the CW mode.

5. Key the PTT switch on the microphone and look at the light bulb. The light should turn on if the coupler has completed its' tuning cycle and if the radio is transmitting.



6. For further testing, follow steps 4 & 5 of the radio test procedure on page 17. Note: The light bulb might not turn on immediately if coupler has not yet been tuned for the frequency of the transmitter. The output power (light-bulb brightness) is greatest when coupler is properly tuned.

This test will ensure that the radio and coupler are working properly.

## 9.0 Five Golden Rules of HF Installation

These rules apply to all types of stations, including base, mobile, airborne and marine. They are very important for planning and installing your HF system, if you want to achieve good communications.

1. Install transceiver as close to operation site and power supply system as possible (whether an external power supply or battery system).
2. The antenna must be installed in an open space and as far as possible from your operating point. Ex: on a sailboat, use the backstay as the antenna, since it is the farthest point away from the rest of the vessel.
3. The antenna coupler must be installed at the base of the antenna.
4. Always create your own ground with radial wire or copper straps. They will guarantee a solid and proper ground system.
5. All cables - power supply, control or coaxial - must always be as short as possible and/or necessary. Any excess cable should be shortened to the proper length - never coiled.

Following these rules will minimize marginal installations and problem sources such as RF feedback in the radio, power supply or cables and "hot" or RF burning microphones. If all 5 above points are followed during the design and installation of your HF system, the operator can expect top performance. Further information regarding applications, installation and operation can be downloaded from our website [www.sgcworld.com](http://www.sgcworld.com). These publications include:

- HF User's Guide
- Go Mobile at 500 Watts
- Stealth Antennas
- Smartuner Antenna Coupler Manuals

**This manual is produced as a guideline for the SG-237 antenna coupler. Performance and results may vary and SGC does not warrant any installation or any result. This manual is subject to change without notice.**

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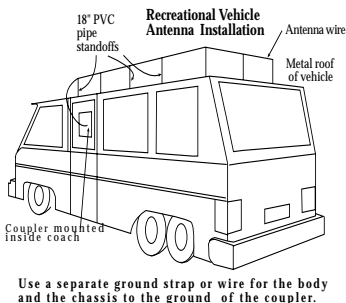
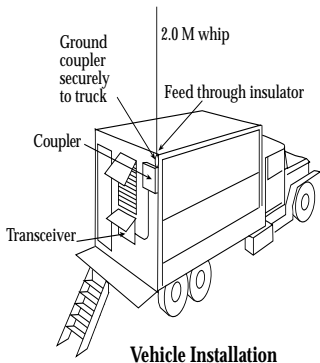
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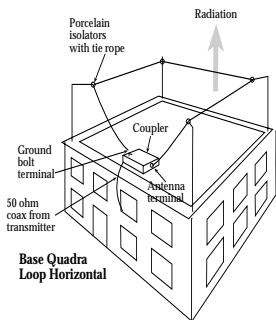
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# 10.0 Selected Antenna Configurations

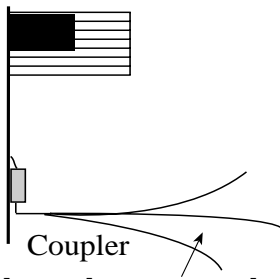


**10.1 Automobiles:** RVs or trailers provide an excellent base to install effective low cost antennas, and end feed or loop antennas can be used.



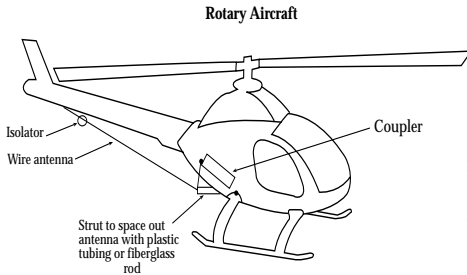
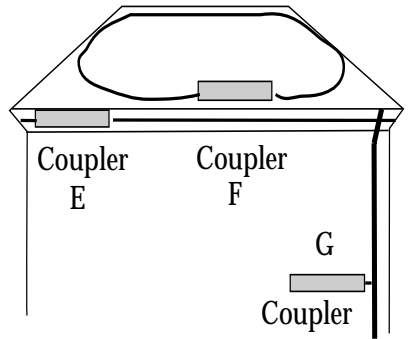
**10.2 Buildings:** The horizontal quad loop is a groundless antenna for high angle radiation and is ideal for HF communications up to 500 miles in the frequency range of 2 to 10 MHz. This configuration provides optimum near-right angle reflection to the ionosphere for short-range communications.

**10.3 Flagpole:** If a flagpole is made of PVC pipe, it is easy to tape a large gauge wire to the inside of the pipe and use a good counterpoise. Typical flagpoles are 25 to 35 feet in height and offer excellent performance on all bands.



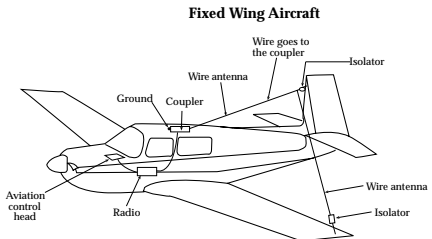
**At least three ground radials longer than the flag pole**

**10.4 Roofs/Walls:** E. Under a roof overhang, all kinds of wire antennas may be installed.  
 F. All types of antennas may be hidden inside the roof of a building that uses non-metallic roofing materials. Loop antennas are good for this type of installation.  
 G. A downspout, rain gutter antenna works well if the piping and gutter are aluminum.



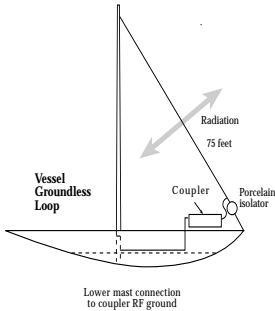
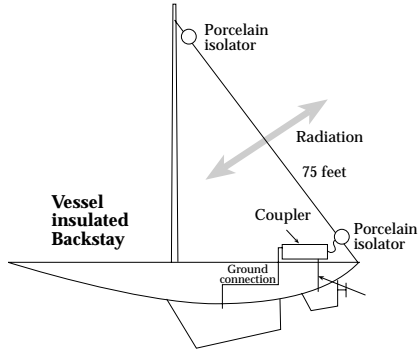
**10.5 Helicopters:** The Smarttuner will also match well the more common wire antenna from fuselage to vertical stabilizer (and continuing to a wing tip, if desired) and a long wire antenna under the tail rotor of helicopters.

**10.6 Airplanes:** When installed in an aircraft, the Smarttuner will operate well with a shunt-fed antenna. This is generally a 13-foot piece of metal that mounts on the fuselage and is grounded to the aircraft at one end.



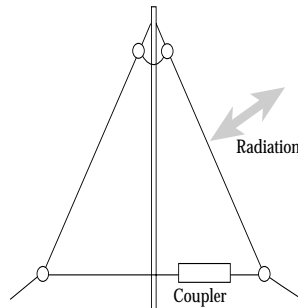
### 10.7 Insulated Backstay:

The coupler must be placed as close as possible to the base of the backstay antenna. Connect the RF ground terminal to all of the metal parts or structures of the boat.

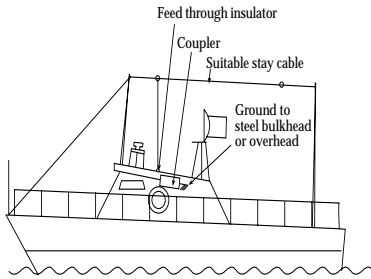


**10.8 Triangular Loop Antenna:** This antenna for sailboats is designed to operate in a groundless environment and still provide high performance. This type of installation will require only one insulator point on the bottom back stay and an electrical connection on top of the mast and the stay. The grounded side of the coupler should be connected to the bottom of the mast.

**10.9 Delta Loop Antennas:** These are ideally suited to long range communications due to their low angle. This configuration is best for communications ranging from 500 to 5000 miles in the HF frequency range of 4 to 22 MHz. Noise rejection is excellent. Because the antenna system is not connected to a ground, noise rejection is enhanced.



**Base Delta Loop**



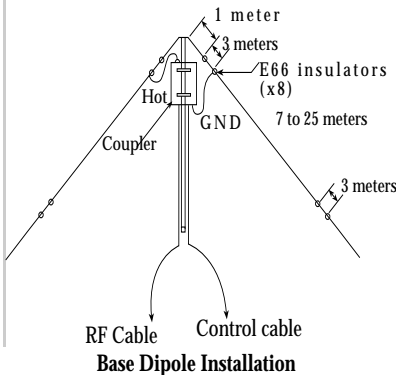
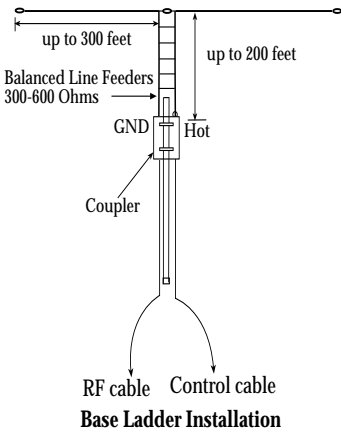
**Motor Vessel Installation**

### 10.10 Long Wire Antenna:

These on a fishing vessel perform well and are very efficient because antenna lengths of 50 feet or more can be installed without any difficulties. If vessel is not of a metal structure 3 radial wires as long as possible can be connected to the coupler and spread on the lower bottom part of the vessel.

### 10.11 Ladder feed Antenna:

These may be used if necessary, however, installation of the coupler directly at the antenna is preferred for higher efficiency.



### 10.12 "V" Antennas:

Both "V" and inverted "V" antennas are convenient for limited space installations and increase of directivity.

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# 11.0 SGC Limited Product Warranty

## And SOFTWARE LICENSE

### SG-237 & SG-237 Porta - 90 Days Parts & Labor

### SG-237 PCB - 30 Days Parts & Labor

This manual is produced as a guideline for the SG-237 antenna coupler. Performance and results may vary and SGC does not warrant any installation or any result. This manual is subject to change without notice. You have purchased an SGC equipment product together with a license to use the software installed in that product. Please return the warranty registration card that accompanies this product, so that we can assure that you receive proper warranty service and important notices that may affect the product. This SGC product is warranted to be free from defects in workmanship and material for a period of days from the original buyer's date of purchase. In the event of a defect, malfunction or failure of which SGC receives notice during that time period, SGC, at its' option, will repair or replace the product free of charge to the buyer. The buyer must contact SGC for a Return Material Authorization Number (RMA) and deliver the product back to SGC with this RMA number and written proof as to date of purchase. SGC will ship a new or repaired product to the buyer, reserving discretionary right to return a newer model that offers at least equal performance. The foregoing warranty extends to the original buyer and does not include (a) buyer's cost to return the product to SGC, (b) buyer's costs to remove or reinstall the product for warranty work, or (c) added costs of special expedited shipment that may be requested by buyer. Except for the limited warranty stated above, and to the full extent permitted by law, SGC disclaims any other express or implied warranties and liability for any incidental, consequential, special or exemplary damages in connection with its product, even if SGC or its agents are advised that such damages are foreseeable. (Note: Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above exclusion may not apply to you). There is no warranty with respect to (a) the product's transmission range or geographical coverage which can vary by location (b) non-performance caused by using an inadequate or improper antenna or grounding system or (c) routine maintenance, periodic adjustment and performance testing of the product or system. SGC customarily charges a flat fee for repairs performed outside of the warranty coverage. To inquire about such charges, please contact SGC. SGC warrants that the SOFTWARE included in this product will perform in substantial accordance with the documentation. SGC grants to the original end user of its product a non-exclusive worldwide license to operate the software installed therein. This license shall be transferred to any person or entity that subsequently acquires lawful ownership of the product. This license shall be limited to using the software for contemplated operation of SGC's product. This license does not permit any end user to (a) modify or adapt SGC's software or to merge it into another program (b) reverse engineer, disassemble, or otherwise attempt to discover SGC's software source code or (c) sub license or otherwise transfer SGC's software for any use other than operating the product originally purchased from SGC.

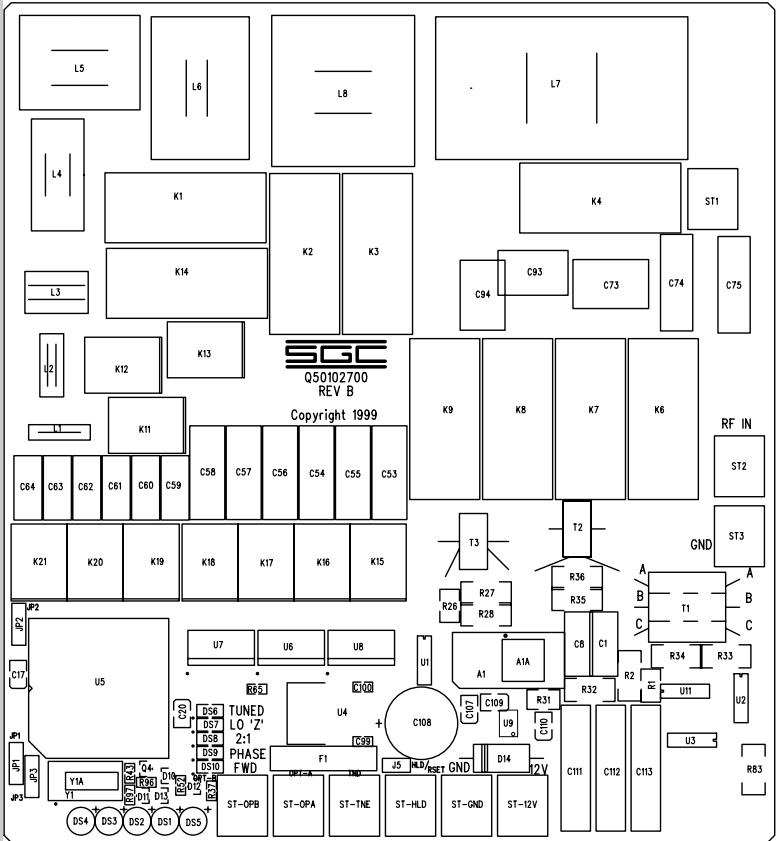
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# 12.0 Component Location / Schematics



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SILKSCREEN TOP

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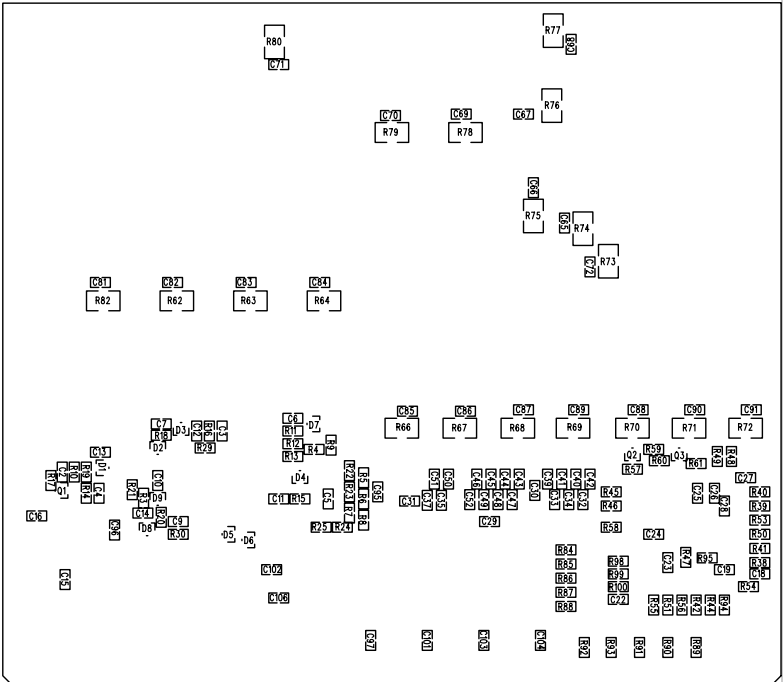
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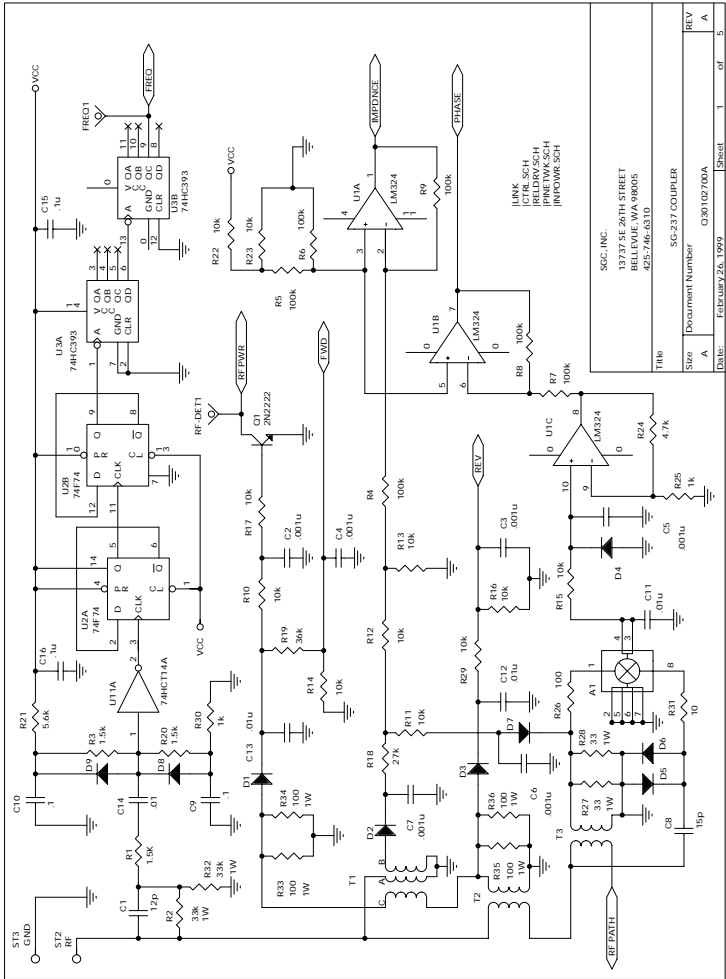
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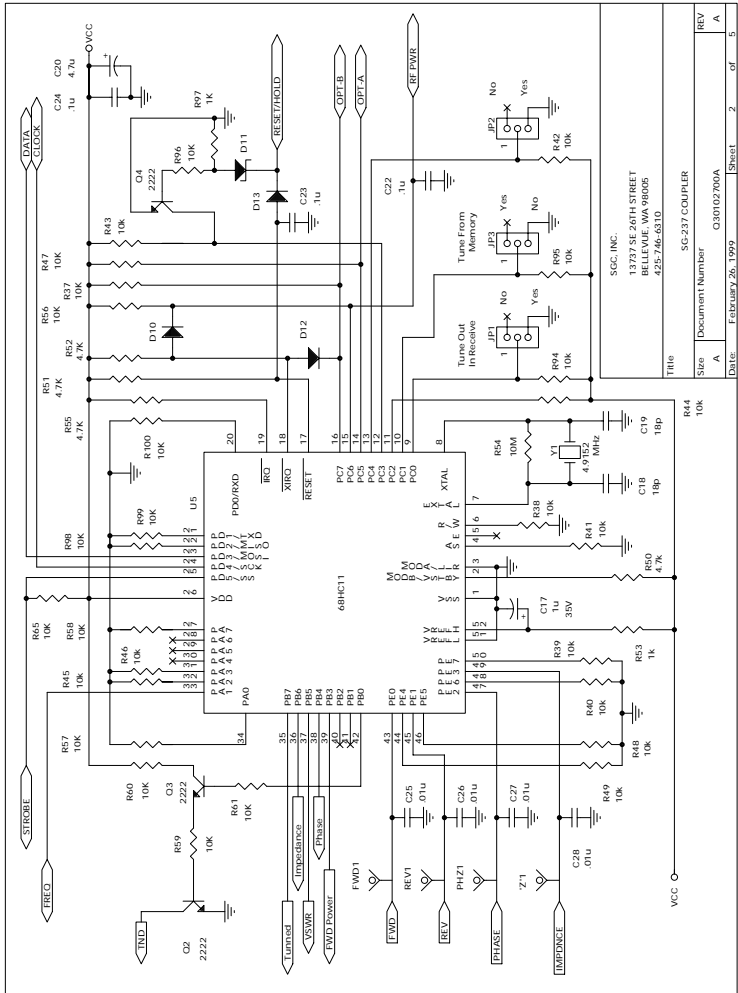
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TRN:	SG-237 COUPLER
Size	Document Number
Rev	O.80102700A
Date:	February 26, 1999
Sheet	1 of 5

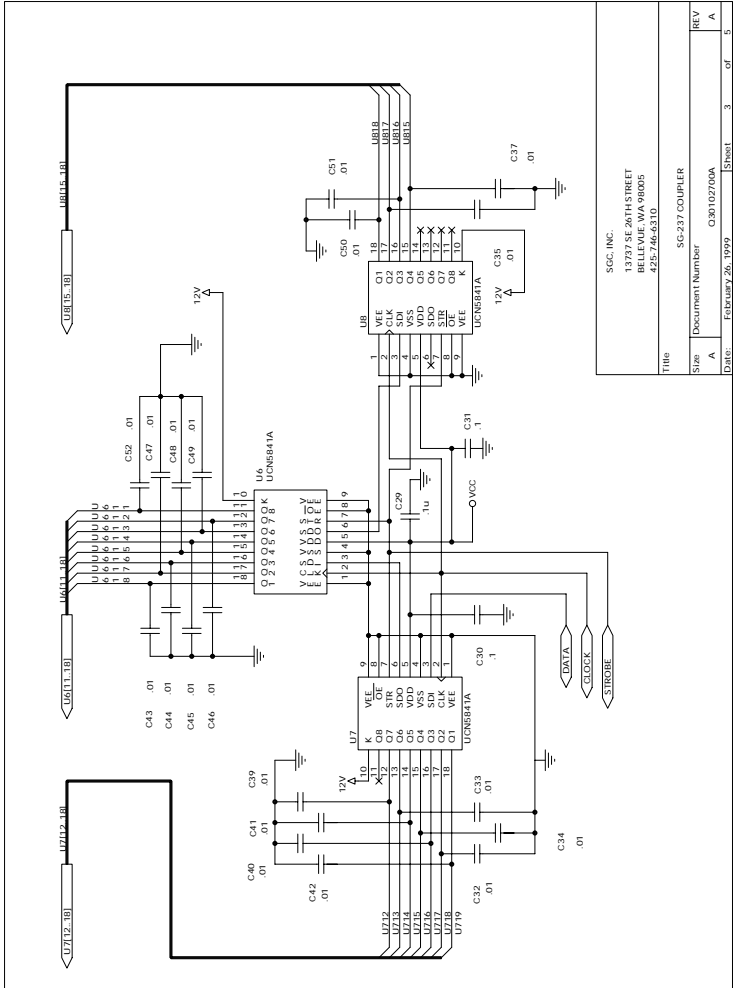
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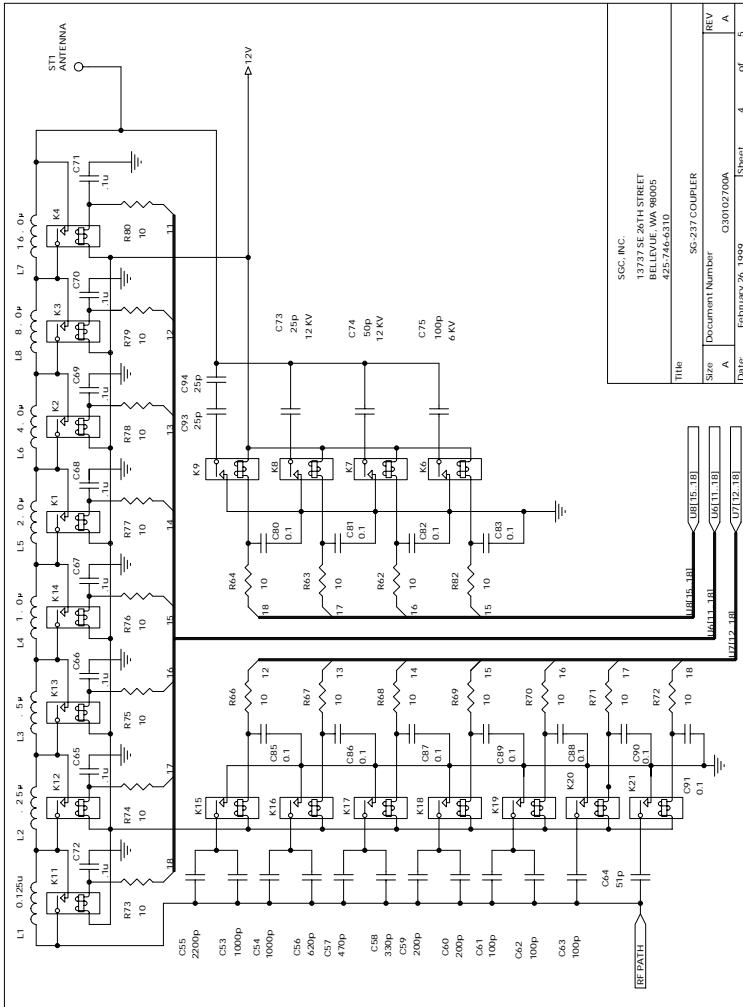
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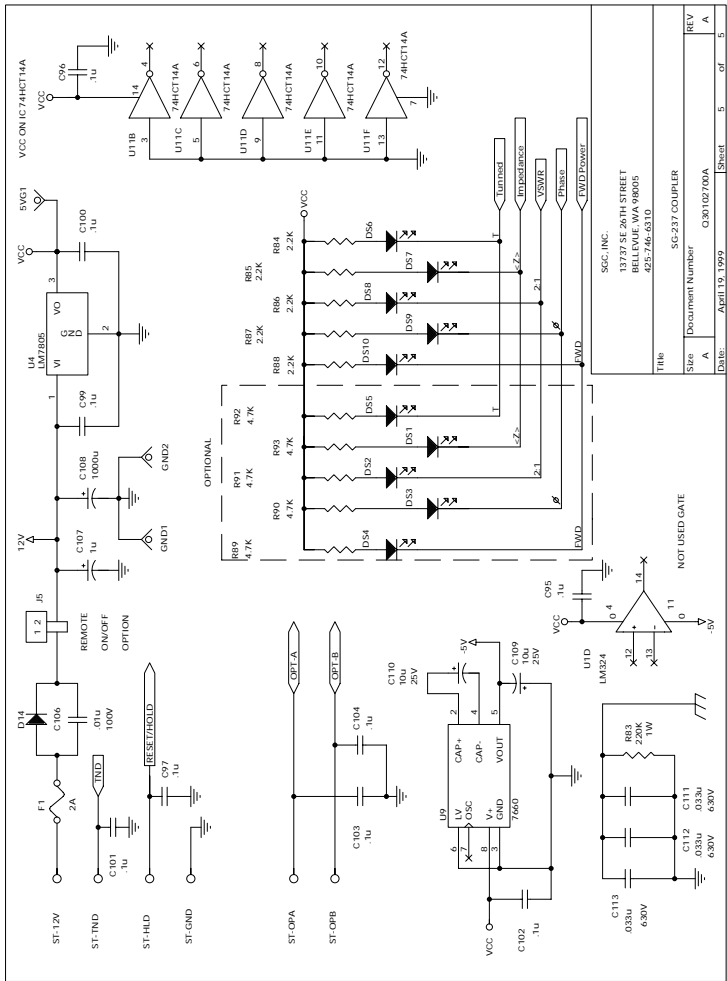


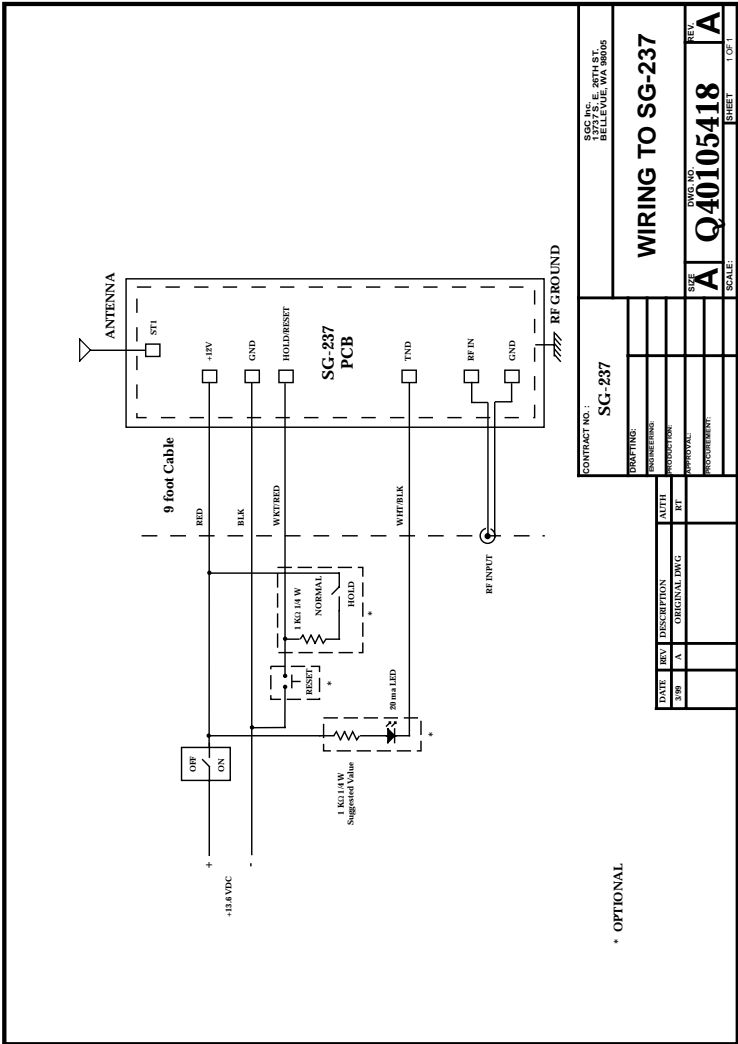
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DATE	REV	DESCRIPTION	AUTH
3/99	A	ORIGINAL DWG	RT
DRAWING		PRODUCTION	
APPROVAL		REQUIREMENT	
SIZE	DWG NO	REV	
<b>A</b>	<b>Q40105418</b>	<b>A</b>	
SCALE:		SHEET 1 OF 1	

## 13.0 SG-237 Porta

### 13.1 SG-237 Porta Supplied Items

- Manual
- SG-237 Porta
- RF Ground System (4 radials of 12 feet each)
- Power/RF Cable 9 foot

### 13.2 Connections

Drawing Q40105420 is the diagram of the antenna coupler connections. RF input and ground is applied to the PL-259 connector on the end of the cable, +13.6 VDC is connected to the red wire - ground to the black wire, and an appropriate antenna and RF Ground System are connected to the antenna stud and the RF ground stud respectively.

### 13.3 Description

The SG-237 Porta is a small portable version of the SG-237 coupler. It is self contained with low current consumption making it ideal for all field applications.

For quick mobile setup or base operation. The unit is light, agile, portable and efficient (300ma). For any HF SSB operating 1.8 to 60 MHz.



Operator can use a ladder feed or end fed antenna.



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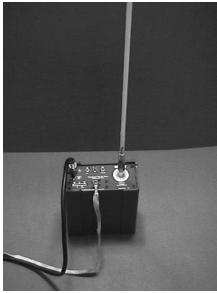
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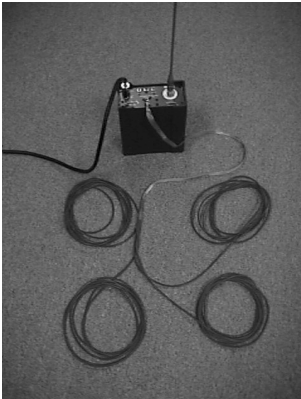




Unit is stable enough to be self-supporting on the ground (antenna not supplied).



SG-237 Porta can be setup for temporary communications; installed on a balcony or ground location. Unit is small enough to be hand held.



The SG-237 Porta is supplied with a 9 ft. single jacketed power cord and coaxial cable, and a ground system of radial wires, each 12 ft. long, as shown (antenna not supplied).

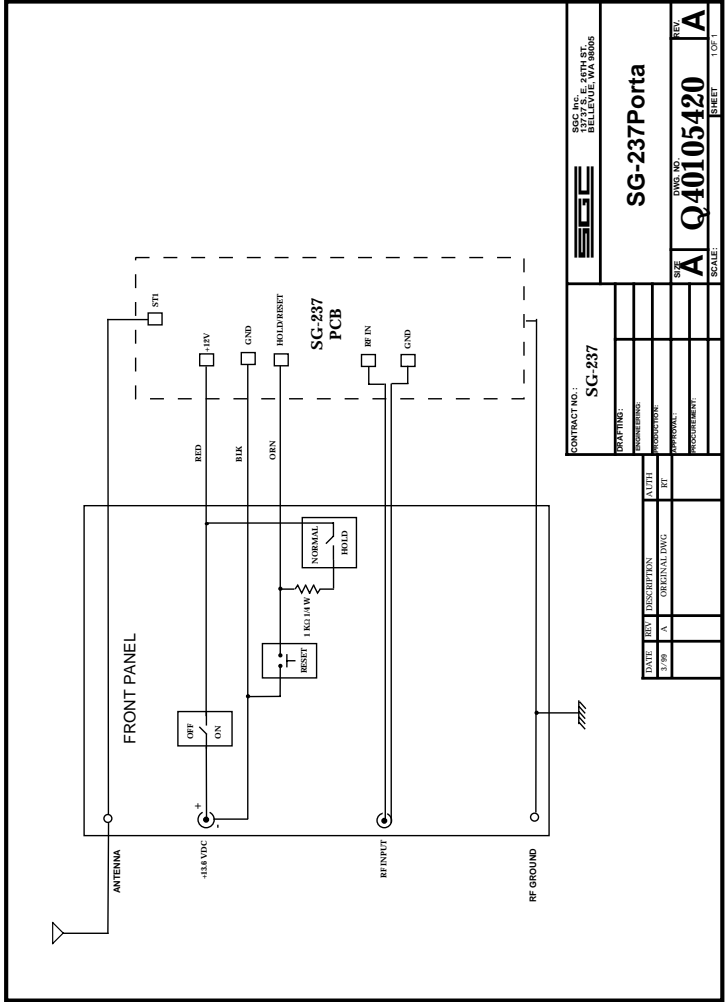
**Note: It is important that the ground radials and cable are never coiled. They must always be in a straight configuration. Always eliminate extra cable.**

Any 9 ft. whip (either fiberglass or stainless steel) will provide good operations above 3.5 MHz, as shown.

An antenna is not included with the SG-237 Porta. We recommend the SG-307 whip antenna.

For operation down to 1.8 MHz, we recommend at least 28 ft. wire be used, or a loop antenna 20 x 20 ft.





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## 14.0 SG-237 PCB

### 14.1 Supplied Items

- Manual
- SG-237 PCB

### 14.2 Connection

Drawing Q40105419 is the wiring diagram of the antenna coupler. RF input and ground is applied to terminals marked RF(ST2) and GND(ST3). +13.6VDC and ground is connected to the terminals marked +12 VDC(ST-12V) and GND(ST-GND), and an appropriate antenna and RF ground system are connected to the ST1 screw and the two RF ground holes respectively. The TND (ST-TND) line can be connected to a radio such as the SG-2000 or a LED.

### 14.3 Special PCB Note

The SG-237 PCB is suitable for retrofits and installation in older radios. However, we do not recommend use by those unfamiliar with HF technology. Because technical expertise is critical to achieving good operation of the SG-237, SGC limits sales of the SG-237 PCB to experienced HF professionals.

Note that VHF or UHF basic physics differ substantially from HF.

CONTRACT NO.:  
**SG-237**

DESIGNING:	
ENGINEERING:	
PRODUCTION:	
APPROVAL:	
PROCUREMENT:	

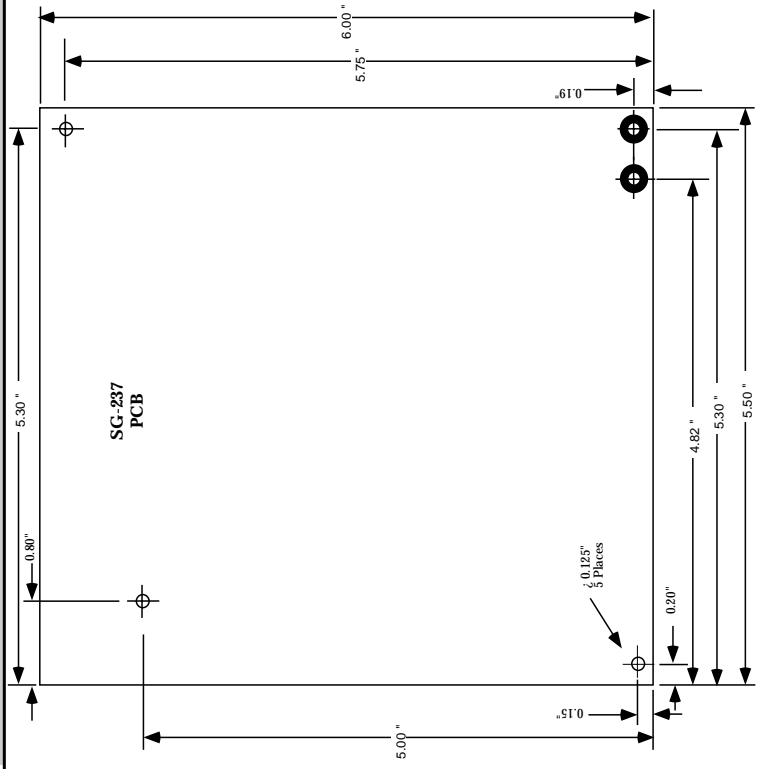
DATE	BY	DESCRIPTION	AUTH.
3/99	A	ORIGINAL DWG	RT



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**MOUNTING HOLES  
FOR SG-237 PCB**

SIZE	DWG. NO.	REV.
<b>A</b>	<b>Q60105419</b>	
SCALE: 1:1		SHEET 1 OF 1



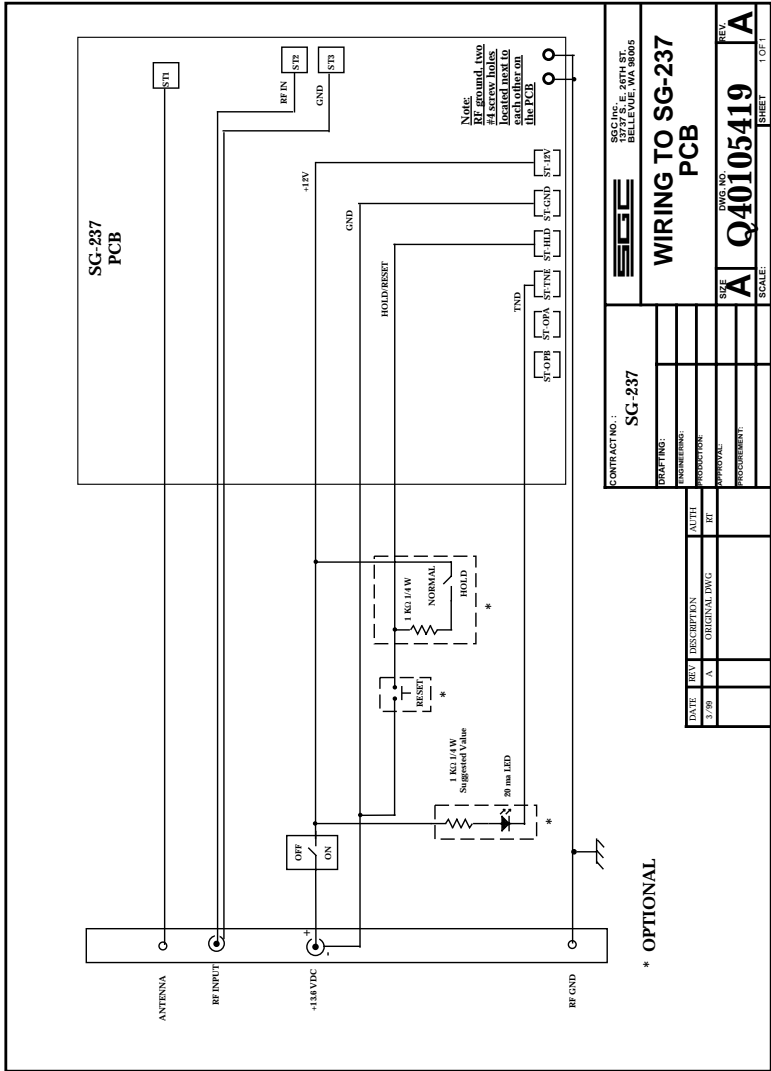
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**SGC**

CONTRACT NO.: **SG-237**

DRAWING: **WIRING TO SG-237 PCB**

DATE: 3/98

REV: A

DESCRIPTION: ORIGINAL DWG

AUTH: RT

PRODUCTION:

APPROVAL:

DISCREPANCY:

SIZE: **A**

DWG NO.: **Q40105419**

REV: **A**

SCALE:

SHEET 1 OF 1

\* OPTIONAL



# 15.0 QMS System

## Introduction

SGC's QMS (Quick Mount System) is one of the many outstanding products manufactured by SGC, Inc. that incorporate the latest technological developments in both design and craftsmanship. Featuring state of the art technology in microprocessor-based communication equipment, the QMS represents high reliability backed by over three decades of communication experience.

## Unpacking QMS

We recommend unpacking the QMS antenna system and inspecting the contents. This is necessary to ensure that no damage has occurred due to shipping and that all items are accounted for as verified from the packing list as follows:

One Manual

One Warranty Card

One QMS Assembly complete with SG-237 coupler and four straps (each three feet long)

## QMS Installation Instructions

The QMS (Quick Mount System) antenna and coupler system can be mounted in virtually any location convenient to the user. Some consideration may be given, however, to the items listed below:

### Installation Considerations

1. Locate the QMS system as far from the engine as possible. This should reduce interference generated by the engine, spark plug noise, etc. from getting into the antenna system.
2. If possible, mounting your QMS in an area clear of objects will reduce the danger of damaging the QMS. For instance, if driving in rough terrain, the QMS is likely to be hit by trees, stumps, or rocks. If the unit were mounted on the back of the vehicle, damage would be less likely to occur than if a side mount was used.
3. If you will be traveling in an area where overhead restrictions prevent use of your SG-307 antenna, the antenna should be folded down and secured to prevent damage from brush, trees, or

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low structures.

4. When connecting the coupler to the radio/transceiver, a passageway for the control cable (consisting of an RG-58 coax cable, control power, and ground, plus the optional tuned indicator wire) will need to be provided.

5. Once a location for the QMS has been selected, mounting becomes a simple task. The QMS enclosure mounts in virtually any attitude and the straps can be moved to either side of the enclosure to accommodate the vehicle.

## Common Car Installation



15.0.1

The QMS-37 can be mounted in minutes on any car, in any position and without drilling any holes. (Antenna not supplied)

15.0.2

An antenna swivel mount is included for easy antenna position, in any direction. (Spring not supplied)



15.0.3



The QMS-37 can easily be mounted on a passenger door window.

The antenna and spring are not included with the system. Suggested antennas are a 9 ft. whip either fiberglass or stainless steel, or the SG-307 antenna with a spring at the base.



15.0.4

Straps can be mounted around the door or with hooks on the top and bottom edges of the door.

14.0.5 A ground can be connected either temporarily or permanently next to the door hinges. 15.0.6



Preferred installation locations are at the highest point on the vehicle.



15.0.7

The straps must be tight to ensure that the suction cups are well compressed. 15.0.8



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15.0.9

Side mounting over the back wheel is a convenient location for lower profile installations.



This configuration provides a very secure installation as the straps are short and taut.

15.0.10

15.0.12

Top trunk mounting also represents a good low profile installation.

15.0.11



## Sport Utility Vehicle Installation



15.0.13

Any fairly flat area is a convenient installation location. For proper radiation, the higher locations are the best.

15.0.14



15.0.15



You may use rack, door, or trunk edges for secure mounting.

15.0.16

Suction cups must be completely compressed for reliable installation as shown.



15.0.17



Four rubber rollers are supplied to avoid vibration of strap spans longer than 6 inches. Straps must never exceed two feet on either side. The rubber rollers also help increase the strap tension.

The ground strap should run together with the strap between the body of the vehicle and the coupler - and then bolt to the chassis as shown on next page.

15.0.18

The antenna can be rotated in any direction with the four way QMS-37 mount.





15.0.19

15.0.20

Close-ups of ground strap location and installation.



15.0.21

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Always install coupler and antenna as far away as possible from the radio and engine as shown in the picture below.



15.0.22

## Installation Precautions

To ensure safe operation of your QMS system, the following in mechanical, and electrical precautions should always be taken:

1. Insure that all four straps are pulled down tightly and the suction cup feet have been securely compressed.
2. Insure that the ground braid is attached to a good vehicle ground system. Do not run ground currents through any hinges. Be sure to make the ground braid as short as possible. Remove all paint and rust from your grounding area. Remember, your ground system is one half of your antenna system.
3. Locate the control wire to the QMS, from the transceiver/radio, away from any other wiring inside your vehicle. This control wire contains a high power RF coax cable which can radiate into other wires (such as your head-to-transceiver control cables) causing feedback in your transceiver.
4. The webbing, buckles, and hooks of your QMS have a rating of 1,000 pounds. Ensure that the hooks are attached to a suitable structure, such as a trunk lid, or something that will not cave in when the straps are pulled tightly to secure the unit.
5. When the QMS system is securely fastened to your vehicle, route the control cable to your transceiver. Any 100 watt PEP, 50  $\Omega$  transceiver may be used. The control cable consists of four wires: one RG-58 coax cable and three small wires (for connections, refer to the SGC coupler manual).
6. Refer to QMS system illustration for dimensions and mounting details. When you are confident that items 1 through 5 have been thoroughly checked, you are ready to install your antenna. Be sure to secure all items with the appropriate tool and to read all product manuals prior to installation or operation.

In no case should the operator use fewer than the four straps provided to secure the unit. The suction cups alone will not provide sufficient mounting for the QMS.

**WARNING:** If you do not properly and securely attach this unit to the vehicle and it comes loose, the speed of the vehicle may cause the unit to injure others.

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## General Installation Information

The mobile communication tips found below apply to any mobile installation, not merely to the QMS or other SGC product.

- For the best performance and radiation, always mount your antenna system on the highest part of the vehicle. Approximately 3 to 15 dB in radiation performance may be gained in simply re-positioning your antenna system from a low to a high point.
- Never use your antenna system while the antenna is reclining against the body or the roof of the vehicle. In this situation, you may find your antenna system performance varies from 6 to 15dB making it difficult or impossible for your coupler to find a proper tuning position.
- The noise generated in your vehicle can, in some cases, totally obliterate your receiving signal. A noise blanker cannot eliminate the noise; it can only help reduce the consequences associated with the noise generated. It may in some cases give you a clearer signal.
- The most efficient way to approach a vehicular noise problem is to eliminate the noise at its source. Upon finding the source, use the appropriate technique to eliminate the noise, replacing the defective item if need be. Use only the appropriate filter component to filter out any noise (before it radiates to your antenna).
- For the connection to the battery system of your radio, use a heavy gauge wire (not less than six gauge). Never use your chassis ground return for your negative line connection. Doing so will cause you to lose too much in line voltage and pick up an unnecessary electrical vehicle noise. Always make a direct connection from the radio to the battery. Remember you need as much input power as possible to generate the most output power possible.
- If you use your radio system often, you may consider the use of a small sealed 40 AH gel cell battery, which requires no service, mounted directly next to your radio. It will provide you the best overall performance and will eliminate a great deal of electrical noise you might find in your line.

Use of the gel cell battery may require a lesser gauge wire to re-charge, in comparison to the large wire required to connect the radio directly to the main battery.

• In the charging line of this auxiliary battery, you may want a diode of 100 Amp. capacity to allow the battery to be charged, so as not to discharge with the rest of the electrical system. (You could use this auxiliary battery, in an emergency situation, to jump the main battery. To do this, however, you must provide a local or remote switch to allow the battery to operate the electrical system of the vehicle (temporarily) to start the engine.)

## **Additional Installation Suggestions**

### **Suction Cups**

**Protecting Painted Surfaces** When applying the high suction devices incorporated into the QMS, it is important to observe two important rules:

- Surfaces must be cleaned prior to installation to prevent scratching.
- Surfaces must be protected during removal to prevent marring.

**Eliminating Damage to Painted Surfaces.** The suction cups on your QMS are of extremely high quality. They will provide excellent service for many years provided you follow certain basic cautions when using them:

- When you are applying the suction cups, prepare the surface by cleaning with mild detergent and rinsing thoroughly. The clean surface, free of scratches, will provide superior holding power.
- If the QMS being applied has been used previously, the suction cups should be cleaned with mild detergent and water, then rinsed thoroughly.
- Spread a thin layer of silicon grease, or pharmaceutical grade lubricant such as “Vaseline,” around the edge of the suction cup where it comes in contact with the surface of the vehicle. Refer to Figure A-4 on the following page:

This will prevent slow leakage of air, which will reduce the holding power of the suction cups over time. It will also protect the painted surface. If the surface of the vehicle is very rough, the installation procedure remains the same. The suction cup will have to be pressed against the vehicle surface in the same way, but more lubricant may be necessary.

**Tightening the QMS Straps.** The QMS enclosure must be tightly strapped to the vehicle. To ensure it is properly strapped, grab the

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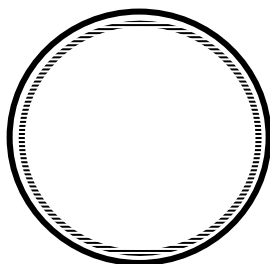
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base of the antenna mounted on the QMS and push firmly up and down. The vehicle should move up and down, but the QMS should not. If the QMS moves and the vehicle does not, increase the tension on the QMS straps.

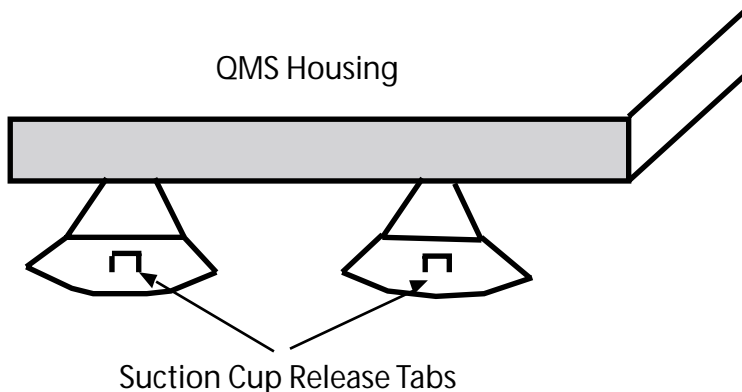
**Figure A-4-Suction Cup (underside view)**



Apply silicon grease to shaded area

Removing the QMS. Wash the vehicle in the area around the suction cups before removing. This will reduce any chance of surface marring.

- Release suction by applying a rolling sideways motion to the tabs on the suction cups as shown in the following drawing:



- To make removal of the unit easier, you may slide a piece of paper between the suction cup and the vehicle surface (see Figure A-3). In this way, each of the suction cup tabs may be loosened sequentially as shown:

Storing Your QMS. To store your QMS unit for long periods of time, apply a thin coating of talcum powder to the suction cups. This treatment increases the life span of rubber products.

## Application Comparison Chart

<b>Model</b>	<b>SG-239</b>	<b>SG-237 PCB</b>	<b>SG-237</b>	<b>SG-237 Porta</b>	<b>SG-230</b>	<b>SG-231</b>	<b>SG-235</b>
<b>Introduction Year</b>	<b>2001</b>	<b>1999</b>	<b>1999</b>	<b>1999</b>	<b>1987</b>	<b>1995</b>	<b>1992</b>
<b>SGC Catalog Number</b>	54-22	54-19	54-18	54-20	54-12	54-17	54-15
<b>Marine</b>			x		x	x	x
<b>Commercial</b>		x	x		x	x	x
<b>Radio Amateur</b>	x	x	x		x	x	x
<b>Aviation</b>	x		x		x	x	
<b>Special Applications</b>	x	x		x			x
<b>Portable</b>	x		x	x		x	
<b>Power Input Range (PEP Watts)</b>	1.5-200	3-100	3-100	3-100	3-200	3-100	3-500
<b>HF Frequency Range</b>	1.8-30 MHz	1.8-60 MHz	1.8-60 MHz	1.8-60 MHz	1.6-30 MHz	1-60 MHz	1.8-30 MHz
<b>Total combinations of elements</b>	1/8 million	1/2 million	1/2 million	1/2 million	1/2 million	Four million	1/2 million
<b>Suggested Retail</b>	\$249.95	\$249.95	\$359.95	\$595.00	\$595.00	\$595.00	\$1595.00

Information is supplied as general information and may change without notice

# Technical Comparison Chart

Description	SG-239	SG-237	SG-230	SG-231	SG-235
HF Frequency Range	1.8 - 30MHz	1.8 - 60MHz	1.6 - 30MHz	1 - 60MHz	1.8 - 30MHz
Power Input Range (PEP watts)	1.5 - 200	3-100	3-200	3-100	3-500
Cont. CW Power (watts) for 100% duty cycle	80	40	80	60	200
Input Impedance Range (ohms)	45-55	45-55	45-55	45-55	45-55
VSWR (Typical)	<2:1	<2:1	<2:1	<1.4:1	<2:1
DC Input Requirement (VDC) Nominal	13.8	13.6	13.6	13.6	13.6
DC Op. Range (VDC)	10 to 18.5	10 to 18	10 to 18	10 to 18	10 to 18
Input Current (avg. amps)	0.23	0.3	0.9	0.5	1.4
Random Set Times (sec)	<2	<4	<2	<4	<2
Recurrent Set Times (ms)	<10	<10	<10	<10	<10
Non-Volatile Memory Addresses	170	170	170	170	170
Total combinations using all elements	1/8 million	half million	half million	four million	half million
Antenna Length operating higher than 3.3 MHz	40 feet min.	8 feet min.	8 feet min.	8 feet min.	23 feet min.
Antenna Length operating from the lowest frequency to 3.3 MHz	100 feet min.	28 feet min.	23 feet min.	23 feet min.	150 feet min.
Elements configuration	Pi & L	Pi & L	Pi & L	Pi & L	Pi & L
Input Capacitance min.	50pf	50pf	100pf	50pf	100pf
Input Capacitance max.	3150pf	6400pf	6400pf	6400pf	6400pf
Inductance minimum	0.125µH	0.125µH	0.25µH	0.125µH	0.125µH
Inductance maximum	15.875µH	32µH	64µH	64µH	32µH
Output Capacitance min	50pf	12.5pf	25pf	12.5pf	12.5pf
Output Capacitance max	740pf	200pf	800pf	400pf	400pf
Installation	Any position	Any position	Any position	Any position	Any position
Operating Temperature	-35C to +70C	-35C to +70C	-35C to +70C	-35C to +70C	-35C to +70C
Environmental	None	Waterproof at immersion of two ft, half hr	Waterproof at immersion of two ft, half hr	Waterproof at immersion of two ft, half hr	Waterproof at immersion of two ft, half hr
Size Overall	7.5"Dx6"Wx1.85"H (19cmx15cmx5cm)	6"Dx7"Wx1.5"H (23cmx18cmx4cm)	16"Dx12"Wx3"H (41cmx31cmx8cm)	11.5"Dx9.5"Wx1.7"H (29cmx24cmx4cm)	16"Dx12"Wx3"H (41cmx31cmx8cm)
Weight	2 lbs. (0.75kg)	<2 lbs. (<0.75kg)	8 lbs. (3.5kg)	3.8 lbs. (1.6kg)	8 lbs. (3.5kg)
Case Construction	Aluminum case	Plastic ABS Waterproof case metal base	Plastic ABS Waterproof case	Plastic ABS Waterproof case metal base	Plastic ABS Waterproof case
Cable(s) (NOTE: All couplers require RF and 12 volt lines only. SGC cables are required for additional features only.)	Terminals	SGC cable, 9 feet coaxial and two power wire input, and RMT tune and SmartLock wire.	SGC cable, 9 ft coaxial and two power wire input, and RMT tune and SmartLock wire	10 feet RG-58 power cable, 10 feet RG-58 coax cable with PL259 connectors	SGC cable, 9 ft coaxial and two power wire input, and RMT tune and SmartLock wire.

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# SG-237 Smartuner™ HF Antenna Coupler



SG-237  
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For normal marine, aviation  
and ham radio installations

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SG-237 PCB  
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For installation in older radios,  
retrofitting and OEM uses



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SG-237 Porta  
Page 28

For mobile, portable  
and field applications

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QMS-37  
Page 38

All-inclusive mobile  
installation



This manual is available for download at  
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