Part No.
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Installation and Setup Manual
for the One-way Signal Booster System
Model Number 60-96-00400-G1

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WARRANTY

This warranty applies for one year from shipping date.

TX RX SYSTEMS INC. warrants its products to be free from defects in material and workmanship at the time of shipment. Our obligation under warranty is limited to replacement or repair at our option, of any such products (with the exception of tubes) which shall have been defective at the time of manufacture. TX RX SYSTEMS INC. reserves the right to replace with merchandise of equal performance although not identical in every way to that originally sold. TX RX SYSTEMS INC. is not liable for damage caused by lightning or other natural disasters. No product will be accepted for repair or replacement without our prior written approval.

All Shipping charges on returned products must be prepaid by the purchaser. TX RX SYSTEMS INC. shall in no event be liable for consequential damages, installation costs or expenses of any nature resulting from the purchase or use of products, whether or not they are used in accordance with instructions. This warranty is in lieu of all other warranties, either expressed or implied, including any implied warranty of merchantability or of fitness. No representative is authorized to assume for TX RX SYSTEMS INC. any other liability or warranty than set forth above in connection with our products or services.

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GENERAL DESCRIPTION

Signal boosters extend radio coverage into areas where abrupt propagation losses prevent reliable communication. This system receives an RF signal, raises its power level, and couples it to an antenna or leaky (radiating) coaxial cable system so that it can be re-radiated. No frequency translation (conversion) occurs with this device.

The one-way signal booster model 60-96-00400-G1 (shown in figure 1) is a broadband, bidirectional single branch system which passes frequencies from 929 to 932 MHz. The system covers a 3 MHz passband width (factory set) and uses linear RF active amplifiers, filters, and DC power sources to adequately boost and re-radiate the passband signals.

The output level of any signal passing through a signal booster is determined by the systems gain specification. All signals passing through a properly operating signal booster are amplified by the

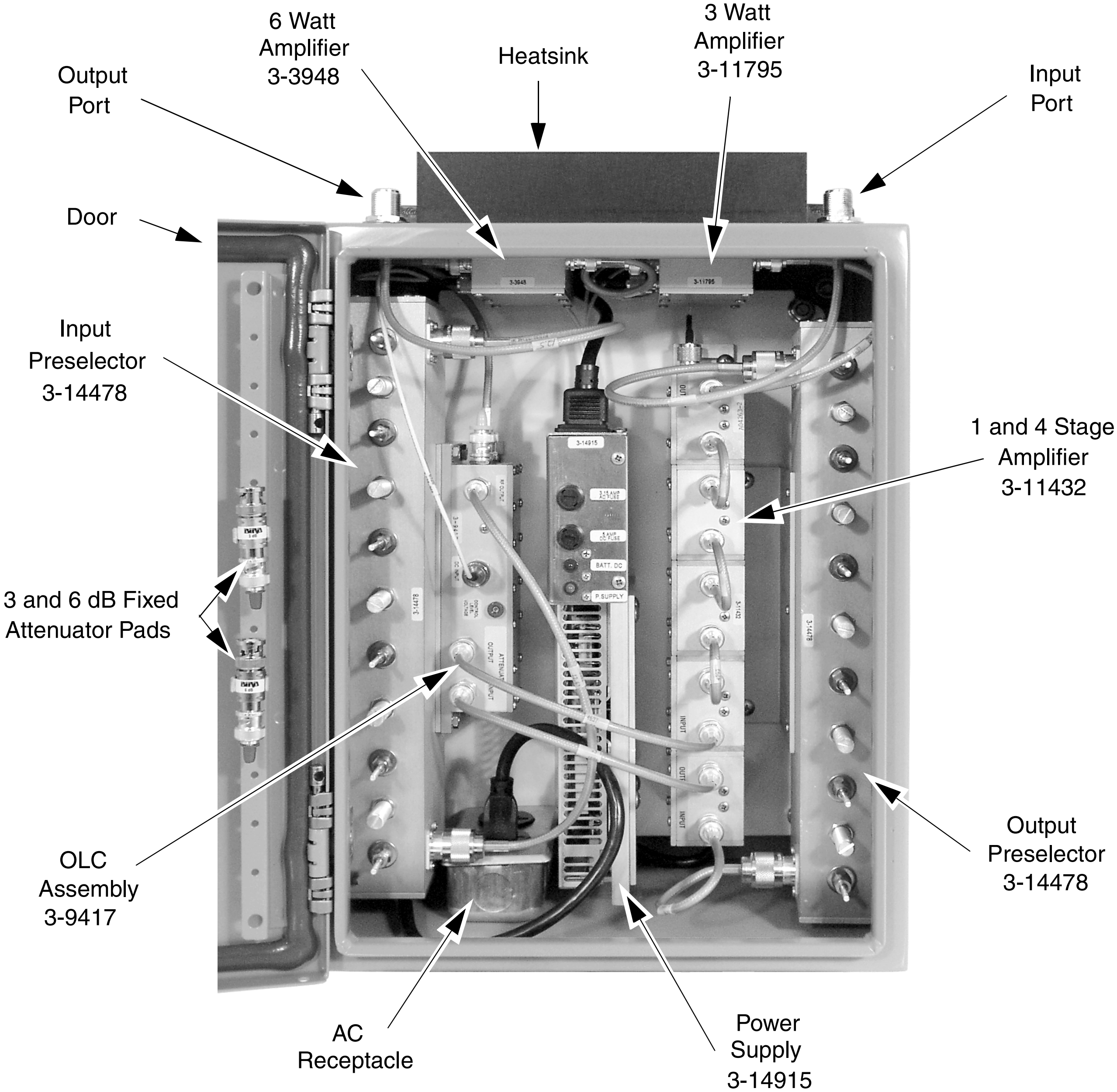

Figure 1: Inside view of the model 60-96-00400-G1 one-way signal booster system.

same amount but will come out at power levels that are related to their respective input level by the gain specification. Signal leveling is not an intended function of a signal booster. Amplifier stages used in this signal booster system may be damaged by excessively strong input signal levels. The system is equipped with Output Leveling Circuitry (OLC) to protect the amplifiers and reduce spurious signals. It is interesting to note that the total power for the multicarrier condition is always less than the maximum single carrier rating. As the number of carriers increases, the difference between the single carrier maximum and the total power of all carriers grows even greater.

Linear power amplifiers (Class-A operation) are used in this application in contrast to the highly efficient Class-C power amplifiers used in the output stages of most FM land mobile transmitters. Linear amplifiers are biased for a relatively high continuous DC current drain that does not change with changing RF drive levels. Class-A amplifiers generally have the lowest efficiency of the various amplifier types, typically in the range of 25 - 33%. Their biggest advantage is faithful reproduction of the input waveform which results in the lowest levels of intermodulation distortion products (IM) of all the classes of amplifiers. The generation of IM distortion is a serious design consideration when two or more channels are simultaneously present in the same amplifier stage.

Filtering is used at the input and output of the signal path to help suppress any IM products that may be inadvertently generated. Signals that exceed the maximum input rating may either damage the signal booster or cause it to generate intermodulation products that exceed the maximum allowed by the FCC or other regulatory agency.

Note About Output Power Ratings

A single maximum output power rating does not apply to broadband signal boosters because the linear amplifiers (Class A) used in them may have to process multiple simultaneous signals. Under these conditions, the questions of power rating becomes more complex.

When more than one signal is amplified, a number of spurious signals will also appear in the amplified output. They are referred to as intermodulation distortion products, more commonly called IM. These spurious products would not be present in a perfectly linear amplifier but as in all things, something short of perfection is realized. Accepted industry practice is to use the Third Order Intercept Point specification of a signal booster to predict the level of IM products. The intercept point is derived from the measurement of an amplifiers 1 dB compression point.

INSTALLATION

The layout of the signal distribution system will be the prime factor in determining the mounting location of the signal booster enclosure. However, safety and serviceability are also key considerations. The unit should be located where it cannot be tampered with by unauthorized personnel yet is easily accessible to service personnel using trouble shooting test equipment such as digital multimeters and spectrum analyzers. Also consider the weight and size of the unit should it become detached from its mounting surfaces for any reason.

Very little is required to install this signal booster. The unit should be bolted in its permanent position using lag bolts or other suitable fasteners. Make sure there is an unobstructed airflow over the external heatsink. Safety and serviceability are key considerations. The signal booster cabinet will stay warm during normal operation so in the interest of equipment longevity, avoid locations that will expose the cabinet to direct sun or areas where the temperature is continually elevated.

The signal booster is designed to be powered from 120 VAC and a conduit entry box is provided at the bottom of the enclosure for bringing the AC line into the cabinet. AC line connections should be made in accordance with local electrical and building codes.

Connection of RF to the unit is made via “N” female connectors located on top of the cabinet. These connectors are individually labeled “Input” and “Output”. Care should be used when making connections to these ports to insure the correct antenna cable is connected to its corresponding input / output port or the system will not work. The use of high quality connectors with gold center pins is advised. Flexible jumper cables made of high quality coax are also acceptable for connecting to rigid cable sections.

CAUTIONARY NOTE

The following cautions are not intended to frighten the user but have been added to make you aware of and help you to avoid the areas where experience has shown us that trouble can occur.

1) Just like the feedback squeal that can occur when the microphone and speaker get too close to each other in a public address system, a signal booster can start to self oscillate. This will occur when the isolation between the input antenna or signal source and the output distribution system does not exceed the signal boosters gain by at least 15 dB. This condition will reduce the effectiveness of the system and may possibly damage the power amplifier stages.

2) The major cause of damage to signal boosters is the application of input RF power levels in excess of the maximum safe input. This can happen inadvertently when connecting a signal generator with full power out to one of the inputs or by a very strong signal that is far stronger than expected. Following the pre-RF connection checks listed next will help to avoid these two problems.

PRE-RF CONNECTION TESTS

Certain characteristics of the signal distribution system should be measured before connecting it to the signal booster. This step is necessary to insure that no conditions exist that could possibly damage the signal booster and should not be skipped for even the most thoroughly designed system. Two characteristics need to be measured; antenna isolation and input signal levels.

Test Equipment

The following equipment is required in order to perform the pre-installation measurements.

1) Signal generator for the frequencies of interest capable of a 0 dBm output level. Modulation is not necessary.

2) Spectrum analyzer that covers the frequencies of interest and is capable of observing signal levels down to -100 dBm.

3) Double shielded coaxial test cables made from RG142 or RG55 coaxial cable.

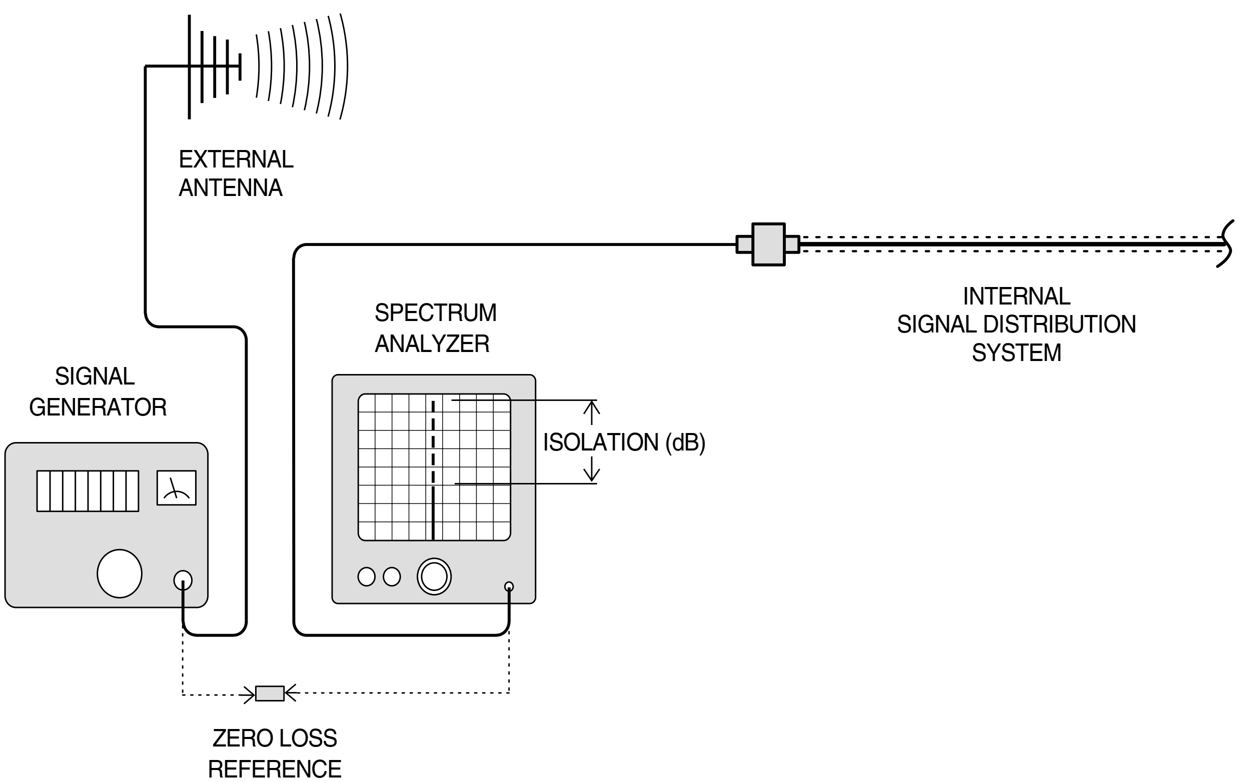

Figure 2: Typical test equipment setup for measuring antenna isolation.

Antenna Isolation
Antenna isolation is the signal path isolation between the two sections of the signal distribution system that are to be connected to the signal boosters antenna ports. Lack of isolation between the input and output antennas can cause the amplifiers in the system to oscillate. This can happen at a high enough level to damage the power amplifier stages. In general, if one or both antenna ports are connected to sections of radiating coaxial cable (lossy cable) the isolation will be more than adequate because of the high coupling loss values that are encountered with this type of cable. When a network of antennas are used for the input and output, this problem is much more likely. Isolation values are relatively easy to measure with a spectrum analyzer and signal generator.

Procedure for Measuring Antenna Isolation

1) Set the signal generator for a 0 dBm output level at the center frequency of the signal boosters passband (930.5 MHz).

2) Set the spectrum analyzer for the same center frequency and a sweep width equal to or just slightly greater than the passband chosen in step one.

3) Connect the test leads of the signal generator and the spectrum analyzer together using a female barrel connector (see figure 2). Observe the signal on the analyzer and adjust the input attenuator of the analyzer for a signal level that just reaches the 0 dBm level at the top of the graticule.

4) Referring to figure 2, connect the generator test lead to one side of the signal distribution system (external antenna) and the spectrum analyzer lead to the other (internal distribution system) and observe the signal level. The difference between this observed level and 0 dBm is the isolation between the sections. If the signal is too weak to observe, the spectrum analyzer's bandwidth may have to be narrowed and its input attenuation reduced. Record the isolation value. **The isolation value measured should exceed the amplifier gain figure by at least 15 dB.**

It is wise to repeat the procedure listed above for measuring antenna isolation, with the signal generator set to frequencies at the passbands edges (929 and 932 MHz) in order to see if the isolation is remaining relatively constant over the complete width of the passband.

Increasing Isolation
If the measured isolation does not exceed the amplifier gain figure by at least 15 dB then modification of the signal distribution system is required. Alternately, the gain of the signal booster can also be reduced to insure the 15 dB specification is met. If the isolation cannot be increased then the amount of gain reduction required is determined as shown in the following example.

EXAMPLE

Gain Reduction (dB) = Minimum Isolation (dB) - Measured Isolation (dB)

If the measured isolation is -75dB and the minimum isolation is -80dB then the amount of gain reduction required is: -80dB - (-75) = -5 dB

Input Signal Levels
Excessive input signal levels can damage the signal booster. Although this problem is less severe in OLC protected systems, strong signals may cause sudden reductions in gain and an associated decrease in the desired output signal strength. Even in the most carefully designed signal distribution systems, unpredictable situations can arise that can cause this trouble. A few of the more common causes are:

a) Unintended signals entering the system. Primarily caused by radios operating on channels that are within the operational bandwidth of the signal booster. Sometimes this will be a transient problem caused by mobile units when they transmit while in close proximity to your system.

b) Hand-held and mobile units that approach much closer than expected to one of the antennas in the signal distribution system.

c) Unexpected signal propagation anomalies. Building geometry can cause signal ducting and other phenomena that cause signal levels that are much stronger (or lower) than expected.

d) Lower than estimated signal attenuation causes signals to be unusually strong. Higher losses can also occur giving weaker signals than desired.

e) Signal booster model with excessive gain. In systems that have an existing signal booster, it is sometimes assumed that an identical unit should be installed when expanding the system to provide extended coverage. In most cases, a signal booster with far less gain than the first is required.

f) Improper installation or application of signal splitters or directional couplers in the signal distribution system. This is usually the cause of too low a signal level but deserves mentioning here. Signal splitting needs to be done with constant impedance signal splitters so that the proper power splitting ratios and VSWR are maintained. Using tee connectors by themselves is inviting trouble. Directional couplers must be connected with regard to their directionality and coupling levels or improper system signal levels may result.

Procedure for Measuring Input Signal Levels

1) Set a spectrum analyzer for the center frequency of the system (930.5 MHz).

2) Set the analyzers sweep width so that the entire passband frequency range can be observed.

3) The analyzers input attenuator should be set to observe input signal levels from approximately -80 dBm to 0 dBm.

4) Connect the analyzer to the section of the signal distribution system that is going to serve as the input (see figure 3).

5) Record the power level (in dBm) of all carriers in the passband frequency range that are significantly greater than the noise floor displayed on the analyzer.

6) To find the total power being applied the calculations listed below must be performed. The conversion chart at the rear of the manual can be used. Here are the steps:

   a) Convert all values in dBm to Watts
   b) Total the power for all carriers in Watts
   c) Convert the total power in Watts to dBm

Example: suppose we have a signal booster with a maximum gain of 70 dB. After checking the input signal levels, it was determined that there are three signals that are significantly greater than the noise floor displayed on the analyzer. These signals have strengths of -45 dBm, -43 dBm and -41 dBm.

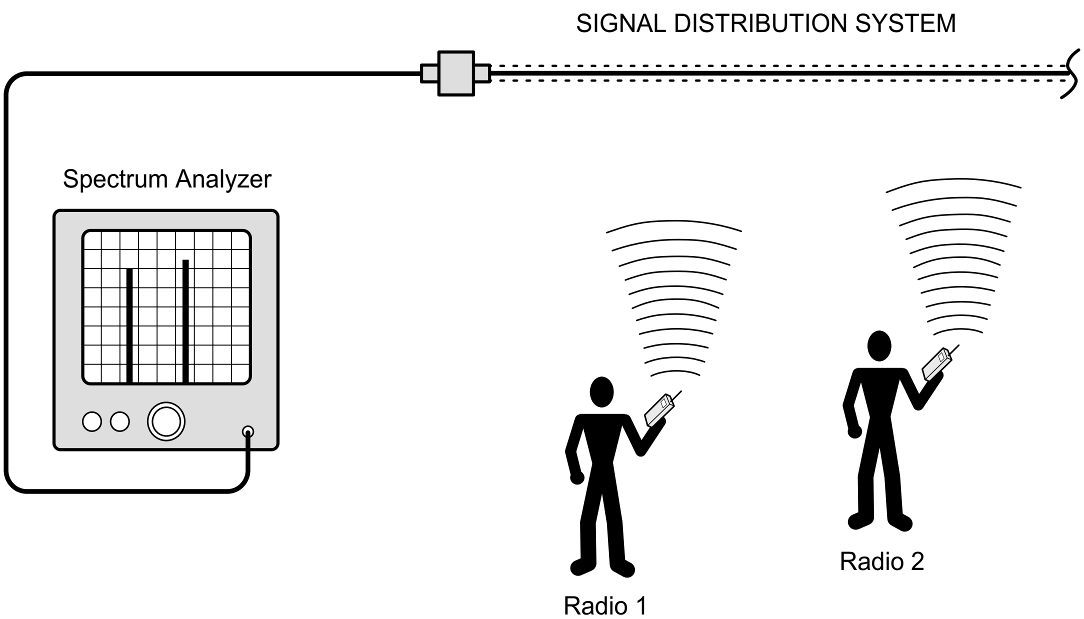

Figure 3: Typical test equipment setup for measuring input signal levels.

First we use the conversion chart at the end of this manual to convert the power levels in dBm to watts so that we can add them together. The power in watts is written in scientific notation but the chart uses computer notation. For example, in the chart, an exponent may be written as E-08. In conventional mathematical notation E-08 is written 10^{-8}.

The total power must be written as a number between 0 and 10 to use the chart. Look up 1.611E-7 in the Watts column. This number falls between -38 and -37 dBm so we chose -37 because it is the next higher value.

Power (dBm)	Power (watts)
-45 dBm	3.16×10^{-8}
-43 dBm	5.01×10^{-8}
-41 dBm	7.94×10^{-8}
TOTAL	$\mathbf{16.11 \times 10^{-8}}$

Reduction of Incoming Signal Strength
Reducing the strength of offending signals may require some or all of the following steps:

a) The addition of extra filtering. Consult TX RX System's sales engineers for help in this respect.

b) Modification of the signal distribution layout by changing the type or location of pickup antennas. This has to be approached in an empirical way, that is, change-and-try until you get the desired results. Sometimes changing from omni to directional antennas will correct the problem.

Setting Signal Booster Gain
The Pre-Installation checks as outlined earlier should have been performed to determine if gain reduction will be necessary for your installation. This can be due to low antenna isolation or excessive input signal levels, or both. The actual amount of gain reduction is determined by the largest number required because of either low isolation or excessive signal levels.

For example, if the results of the isolation measurement indicated the need for a gain reduction of -10 dB but signal level measurements indicate a need for only a -5 dB gain reduction; then 10 dB is the number required since both conditions are satisfied.

Gain Reduction Methods
As shipped from the factory, the system was setup for maximum gain. Gain reduction is accomplished by adding fixed attenuator pads to the input of the pin diode attenuator section of the OLC assembly or where even greater reductions are required, bypassing one of the first driver amp stages. Bypassing of amplifier stages is preferred for large gain reductions so that excessive noise levels are not produced. Use of attenuator pads alone will reduce gain but the signal booster will also amplify the noise generated in the lower level stages. The correct positions for adding fixed pads to the system are shown as dotted symbols on the specification drawings.

CAUTION: Any fixed attenuator pads that are already connected into the booster circuitry have been installed at the factory and should not be removed for any reason. Their function may be other than gain reduction.

A pair of fixed attenuator pads (3 and 6 dB) are supplied which are mounted in holders on the inside of the cabinets front door. The pads' attenuation values are clearly labeled on the body of the attenuator.

Bypassing Amplifier Stages
Sometimes the amount of gain reduction needed is greater than the amount available with the attenuator pads alone. In this case, the second stage of the first driver amplifier may be bypassed. The five stages of the amp are connected together with short lengths of coaxial cable. To bypass the second stage, remove the coax cable that connects the second and third stages. Move the cable from the input connector on the second stage to the corresponding connector on the third stage. The input connector is always the one on the left when facing the side of the amplifier with the BNC connectors. Keep in mind that the total gain reduction is the sum of the added pading plus the loss of gain for the bypassed amplifier stage. Quality 50 ohm terminations should be installed on the open terminals of any bypassed stage.

OPERATION

Power is applied to the signal booster by turning on the power supply assembly (see figure 1). The green LED indicator should come on indicating the power supply assembly is functioning normally. The red LED is not used.

PERFORMANCE SURVEY

It is a good idea to document the performance of the system after installation so that a reference exists for future comparisons. This information can make troubleshooting an interference problem or investigation of a complaint about system performance much easier. If there are coverage problems with a system, this survey will usually reveal them allowing corrective measures to be taken before the system is put into routine use. The following is an outline of how to do such a survey. Because the nature of each installation can be quite different, only a broad outline is given.

1) <u>Measure the gain of the signal booster being careful not to exceed the maximum input level.</u> Figure 4 shows this being done using a signal generator and spectrum analyzer. This is basically a substitution measurement. Record the measured values for each passband.

2) The signal booster system is equipped with a -50 dB signal sampler port following the final output amp (part of the OLC assembly). This port is for the connection of test equipment such as a spectrum analyzer and will allow the observation of the amplifier output at a considerably reduced output level. This decoupling figure needs to be added to a measured signal value in order to arrive at the actual signal level.

3) With a spectrum analyzer connected to the signal sampler port (see figure 5), have personnel with handheld radios move to predetermined points and key their radios. Record the level of these signals as observed on the analyzer and also record the location of the person transmitting. In this way, a map of the systems performance can be generated.

4) For branches that amplify signals coming from a fixed antenna or station, record the level of all the desired incoming signals for future reference.

MAINTENANCE AND REPAIR

Signal boosters manufactured by TX RX Systems, Inc. can function reliably for 10 or more years with little or no maintenance. However, if the amplifiers

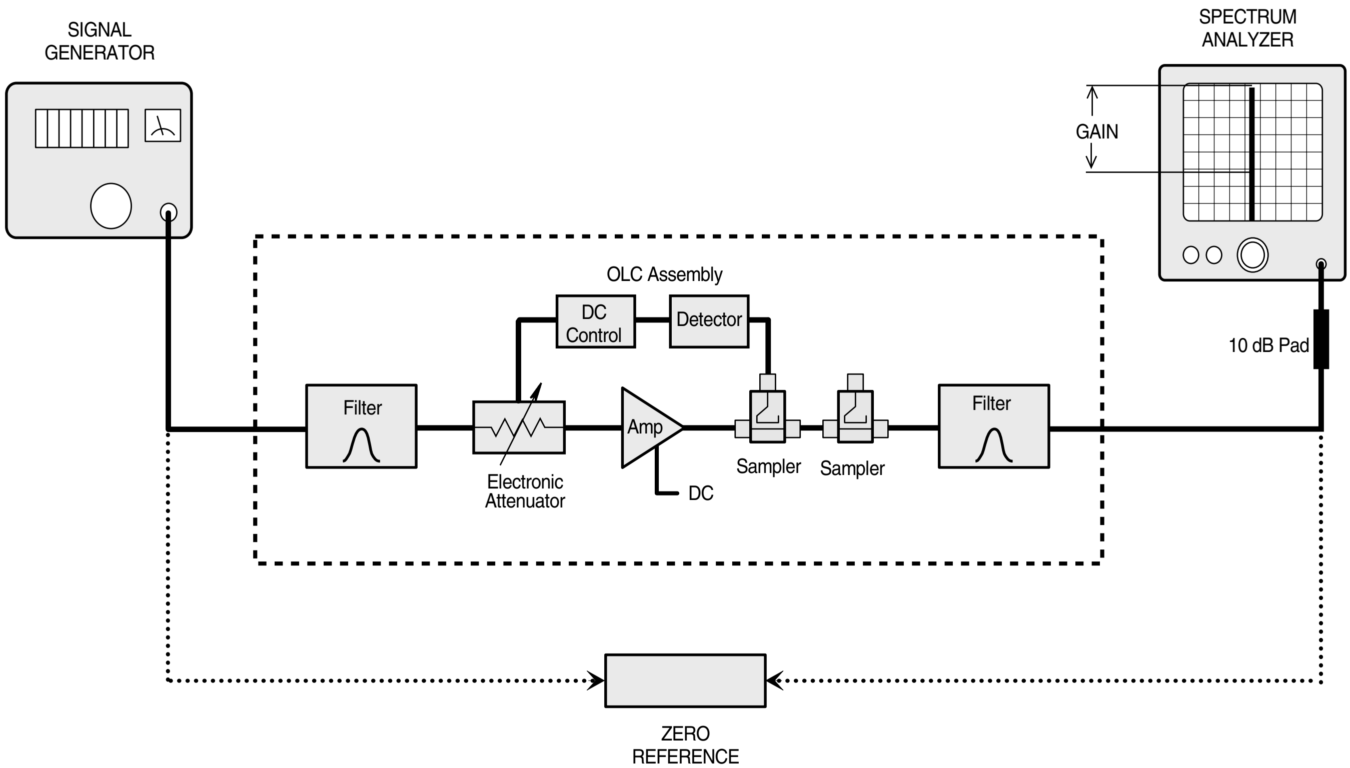

Figure 4: Test equipment interconnection for measuring signal booster gain.

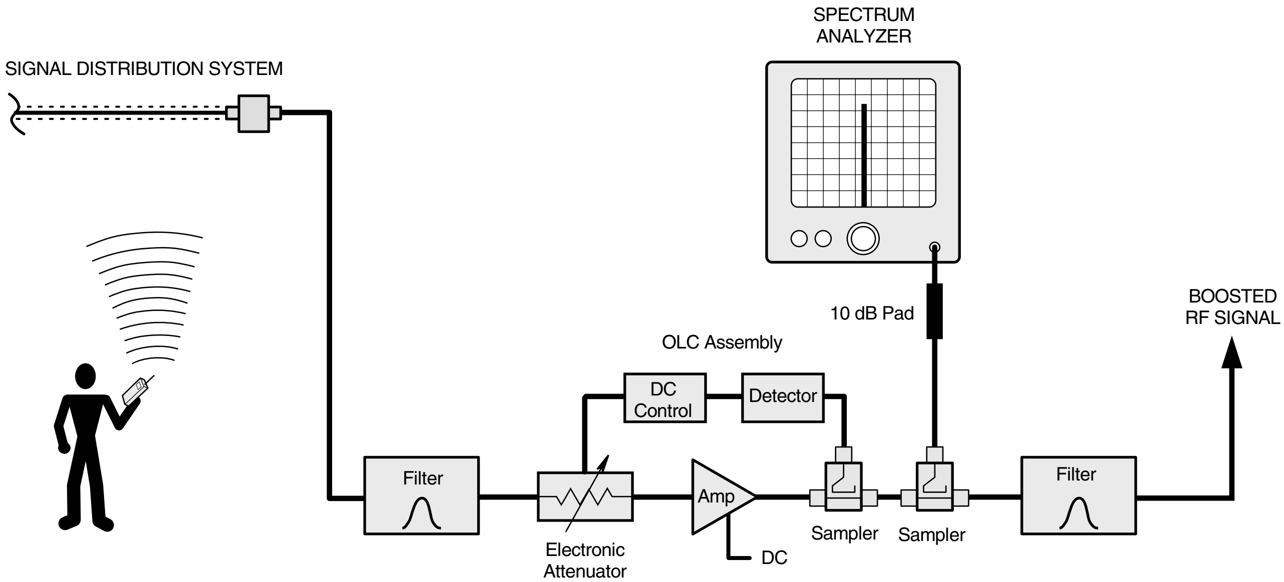

Figure 5: Test equipment interconnection for surveying performance.

are subjected to excessively high signal levels, power surges or lightning strikes, failures may occur. The following procedures may be followed for detecting a malfunctioning unit or as part of a periodic maintenance program.

1) The heatsink area should be cleared of dust and debris.

2) Inspect the unit to see that the power supply LED DC indicator is lit (remove any dust or debris that may obscure the LED). This will verify that DC power is flowing properly. Check all hardware for tightness.

3) Compare system performance to initial performance levels measured when the system was first installed. The lack of signal can be traced to a malfunctioning amplifier by progressive signal monitoring from the output (far end) to the input end of the system noting the area where the signal returns to normal level. The next amplifier toward the output end of the system will probably be the one that failed.

or

Measure the gain at any convenient frequency in the working frequency band to verify that the gain specification is being met. If the gain values fall below that specified for the model check the following:

A) Open the signal booster cabinet and inspect for any loose or broken connections or cables, and repair as necessary.

B) Measure the output of the power supply to see that the proper operating voltage is being maintained.

C) If the operating voltage is proper but the gain is still low, measure the gain of each amplifier stage until the one with low gain is isolated. Replace a low gain amplifier with a new amplifier stage to correct the problem.

DETAILED SUBASSEMBLY DESCRIPTIONS

The following section details the operation of each assembly in the One-Way Signal Booster System.

Preselector Assembly 3-14478

The RF input to the system is first applied to a combline bandpass filter which limits the frequency applied to all subsequent stages. The bandwidth of this filter is determined by the spacing between the tuning rods which are all located on one side of the aluminum housing and vaguely resemble the teeth of a comb (hence the name). This filter is considered to have one section for each tuning rod. the greater the number of sections, the greater the selectivity and ultimate rejection of the filter. These filters are not intended for tuning to other frequency bands. The combline output filters suppress any IM products that may be inadvertently generated.

OLC Assembly 3-9417

Signals that exceed the maximum input rating may either damage the repeater amplifier or cause it to generate intermodulation products that exceed the maximum allowed by the FCC or other regulatory agencies. The addition of the Output Level Control (OLC) circuit helps prevent this from happening. The OLC Assembly (part # 3-9417) is set to maintain a maximum single carrier output power from the 6-watt amplifier of +25 dBm. The assembly contains a signal sampling and detection section, a DC control section and a PIN diode RF attenuator section which is applied ahead of all amplification.

OLC circuitry should not be considered a panacea for a poor system design. One undesirable side affect of OLC is that the signal level of all signals being processed by the branch will be reduced when this circuitry is activated. This means that the performance of the system is actually decreased for all signals in a branch as long as gain reduction is taking place for any one signal in that branch. The implication is that OLC has been designed to handle short term or transient overdrive episodes only.

This circuitry actuates when the predetermined maximum output level is reached. The output power level is sensed with a signal sampler that is built into the OLC assembly. The sampler outputs to a detector circuit which generates a DC voltage that is proportional to the output power level. The proportional DC voltage from the detector is then applied to a control circuit which develops a voltage used to control a variable electronic attenuator. The electronically controlled attenuator is placed at the input end of the amplifier chain and reduces the incoming signal by an amount necessary to keep the power from exceeding the maximum safe level. The gain reduction range is typically 5 - 40 dB which is more than adequate for most real life situations.

The OLC assembly is divided into three shielded compartments; one housing the RF/DC converter, the second a DC control circuit, and the third containing the RF attenuator circuit. A test point is provided for measuring the DC voltage applied to the RF attenuator (see figure 6). Regulated VDC is

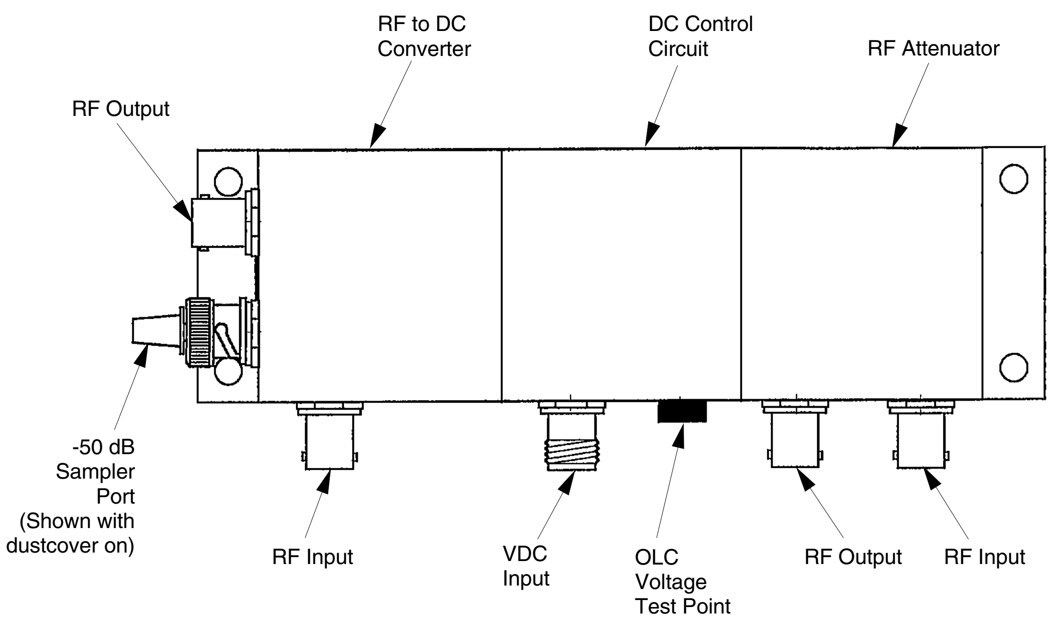

Figure 6: OLC Assembly 3-9417.

supplied to a "TNC" female connector to power this assembly.

The RF to DC converter section of the OLC assembly contains three circuits, a -20 dB sampler which is used to supply the RF signal to the diode detector, and finally a -50 dB sampler which provides a convenience port for connecting test equipment. The detector circuit receives RF from the -20 dB sampler and produces a negative polarity DC output voltage that is proportional to the RF signal. A Schottky Barrier diode (D2) and integrator (R3/C1) are used as the detector.

The DC voltage produced by the RF to DC converter is directly proportional to the output signal strength of the final amplifier. The DC voltage is supplied to the DC control circuit at the non-inverting terminal of op-amp IC2. A variable reference DC voltage is applied to the inverting terminal of the same op-amp. Variable resistor VR2 is used to set the magnitude of this reference voltage and controls the level at which gain reduction will start to occur.

As the signal strength increases, the output voltage of the RF to DC converter, which is of negative polarity, becomes larger. This change causes the output of IC2 to also become increasingly negative. This output voltage is connected via diode D1 to bias the RF attenuator circuit board assembly. As this voltage becomes more negative, the attenuation is increased thus achieving a certain range of gain control. Diode D1 insures that the gain control voltage is always positive and never goes below 0 volts. In actual practice, OLC operation is set to commence when the power output of the final amplifier reaches its maximum two-carrier level.

Two other ICs are mounted on the OLC control circuit board. IC1 is a 10 volt regulator that supplies DC to the other two chips. Variable resistor VR1 is used to set this voltage. IC3 is a voltage inverter that produces -4.5 volts which is applied to the op-amp IC2. This negative voltage allows the output voltage of IC2 to closely approach 0 volts. Two diodes (D1 and D2) are used in series to extend the attenuation range. The diodes are always forward biased with minimum forward resistance and insertion loss occurring at about 20 ma of current.

Pre-Amplifier 3-11432

The pre-amplifier consists of the 400 milliwatt amplifier connected between the input filter assembly and the op-amp/attenuator assembly. The preamplifier is a single stage of the five identical stages found in assembly 3-11432 and is used to insure that a sufficient level of signal is applied to the attenuator.

Each of the five individual stages (part# 3-7718) found in assembly 3-11432 are complete 400 milliwatt amplifiers. They are mounted on a common mounting panel and have a common DC distribution bus running internally between the individual stages. Each stage provides a minimum of 13.2 dB of gain with a power requirement of 21.7 VDC (nominal) and a typical current draw of 120 ma. The maximum single carrier power output is 400 milliwatts.

Each amplifier stage consists of two circuits, the amplifier circuit (3-7725) and the bias regulator circuit (3-10742). Both of these circuits are housed in their own enclosures which are then physically joined together to make up one stage. The circuits are electrically joined using feed-thru capacitors Cf1 and Cf2.

The amplifier circuit uses a linear RF transistor Q1 (Philips part# BFQ34/01) which is operated in a class "A" configuration in order to keep intermodulation distortion to a minimum. The RF transistor is biased for a nominal collector current of 120 ma. A bias regulator circuit is used to keep the collector current constant with changes in temperature. Narrow band matching techniques are used in this amplifier and it will require tuning if the transistor or matching network components are replaced.

The bias regulator circuit uses an Op-Amp comparator IC1 to supply a variable bias current which varies as required to keep the RF transistors collector current constant. Current to the collector of the RF transistor flows through resistor R1. The voltage at the collector side of this resistor is applied to the non-inverting input of IC1. Voltage divider R2 / R4 sets the desired reference voltage on the inverting terminal of IC1. The variable output voltage at pin 6 of IC1 is then applied to the base of the RF transistor. The bias on the RF transistor will now vary in such a way as to keep the voltage at the collector end of R1 equal to the reference voltage provided by divider R2/R4, thus keeping the RF transistor's collector current constant (120 ma nominal).

Repair or replacement of bias circuit components does not necessitate retuning of the amplifier.

First Driver Amplifier 3-11432
The remaining four stages of the five stage assembly (3-11432) are used to form a driver amplifier which amplifies the output of the OLC assembly and applies it to the second driver amp.

Second Driver Amplifier 3-11795
The second driver amplifier is used to provide sufficient amplification to drive the input of the final amp. It uses a single ultra-linear RF transistor. The 2.5 watt rating indicates the maximum safe output from this amplifier using a single carrier. The actual maximum allowable power output with multi-carriers is considerably lower and is determined by the maximum allowable intermodulation product level and is also limited by the collector-emitter breakdown rating of the RF transistor.

This amplifier stage draws a nominal 500 ma. A bias regulator circuit within the amplifier assembly is used to keep the collector current of the RF transistor constant with changes in temperature. This amplifier has a minimum gain of 14 dB, 15 dB typical. The amplifier uses narrow band matching techniques and will require tuning if the transistor or matching network components are replaced.

The bias regulator circuit uses an operational amplifier and a PNP transistor to supply a variable bias current that varies as required to keep the RF transistor collector current constant. Current to the collector of the RF transistor is sampled through resistor R5. The voltage at the collector side of this resistor is applied to the non-inverting input of U1. Voltage divider R6 / R7 sets the desired reference voltage on the inverting terminal of U1. U1 is lifted above chassis ground by the zener diode D2 in order to keep U1 operating below its 18 volt maximum rating.

Resistor R3 and C2 work in combination to prevent U1 from oscillating at audio frequencies. The variable output voltage of U1 biases pass transistor Q1 through the voltage divider R4 / R8. Q1 in turn supplies the current to bias the RF transistor. The bias on the RF transistor varies in such a way as to keep the voltage at the collector end of R5 equal to the reference voltage provided by divider R6 / R7, thus keeping the RF transistor's collector current constant. Repair or replacement of bias circuit components does not necessitate retuning of the amplifier.

Power Amplifier 3-3948
This 6 watt final amplifier uses a single ultra-linear RF transistor. The 6 watt rating indicates the maximum safe power output from this amplifier using a single carrier. The actual maximum allowable power output with multi-carriers is considerably lower and is determined by the maximum allowable intermodulation product level and is also limited by the collector-emitter breakdown rating of the RF transistor. The One-Way Signal Booster systems power specifications appear on the specification drawing.

This stage receives its DC power from the 21 volt regulator and draws a nominal 960 ma. The RF transistor is biased for a nominal collector current of 880 ma. A bias regulator circuit is used to keep the collector current constant with changes in temperature. This stage has a minimum gain of 9 dB, 10 dB typical. This amplifier uses narrow band matching techniques and will require tuning if the transistor or matching network components are replaced.

The bias regulator circuit uses an operational amplifier and a PNP transistor to supply a variable bias current that varies as required to keep the RF transistor collector current constant. Current to the collector of the RF transistor is sampled through resistor R5. The voltage at the collector side of this resistor is applied to the non-inverting input of U1. Voltage divider R6 / R7 sets the desired reference voltage on the inverting terminal of U1. U1 is lifted above chassis ground by the zener diode D2 in order to keep U1 operating below its 18 volt maximum rating.

Resistor R3 and C2 work in combination to prevent U1 from oscillating at audio frequencies. The variable output voltage of U1 biases pass transistor Q1 through the voltage divider R4 / R8. Q1 in turn supplies the current to bias the RF transistor. The bias on the RF transistor varies in such a way as to keep the voltage at the collector end of R5 equal to the reference voltage provided by divider R6 / R7, thus keeping the RF transistor's collector current constant. Repair or replacement of bias circuit components does not necessitate retuning of the amplifier.

Power Conversion Chart

dBm to dBw : Watts : Microvolts

dBm	dBw	Watts	Volts (50Ω)
80	50	100000	2236.07
79	49	79432.82	1992.9
78	48	63095.74	1776.17
77	47	50118.72	1583.01
76	46	39810.72	1410.86
75	45	31622.78	1257.43
74	44	25118.86	1120.69
73	43	19952.62	998.81
72	42	15848.93	890.19
71	41	12589.25	793.39
70	40	10000	707.11
69	39	7943.28	630.21
68	38	6309.57	561.67
67	37	5011.87	500.59
66	36	3981.07	446.15
65	35	3162.28	397.64
64	34	2511.89	354.39
63	33	1995.26	315.85
62	32	1584.89	281.5
61	31	1258.93	250.89
60	30	1000	223.61
59	29	794.33	199.29
58	28	630.96	177.62
57	27	501.19	158.3
56	26	398.11	141.09
55	25	316.23	125.74
54	24	251.19	112.07
53	23	199.53	99.88
52	22	158.49	89.02
51	21	125.89	79.34
50	20	100	70.71
49	19	79.43	63.02
48	18	63.1	56.17
47	17	50.12	50.06
46	16	39.81	44.62
45	15	31.62	39.76
44	14	25.12	35.44
43	13	19.95	31.59
42	12	15.85	28.15
41	11	12.59	25.09

dBm	dBw	Watts	Volts (50Ω)
40	10	10	22.36
39	9	7.94	19.93
38	8	6.31	17.76
37	7	5.01	15.83
36	6	3.98	14.11
35	5	3.16	12.57
34	4	2.51	11.21
33	3	2	9.99
32	2	1.59	8.9
31	1	1.26	7.93
30	0	1	7.07
29	-1	0.79	6.3
28	-2	0.63	5.62
27	-3	0.5	5.01
26	-4	0.4	4.46
25	-5	0.32	3.98
24	-6	0.25	3.54
23	-7	0.2	3.16
22	-8	0.16	2.82
21	-9	0.13	2.51
20	-10	0.1	2.24
19	-11	0.08	1.99
18	-12	0.06	1.78
17	-13	0.05	1.58
16	-14	0.04	1.41
15	-15	0.03	1.26
14	-16	0.03	1.12
13	-17	0.02	1
12	-18	0.02	0.89
11	-19	0.01	0.79
10	-20	0.01	0.71
9	-21	0.01	0.63
8	-22	0.01	0.56
7	-23	0.01	0.5
6	-24	0	0.45
5	-25	0	0.4
4	-26	0	0.35
3	-27	0	0.32
2	-28	0	0.28
1	-29	0	0.25

Power Conversion Chart

dBm to dBw : Watts : Microvolts

dBm	dBw	Watts	uVolts (50Ω)
0	-30	1.0000E-03	223606.8
-1	-31	7.9433E-04	199289.77
-2	-32	6.3096E-04	177617.19
-3	-33	5.0119E-04	158301.49
-4	-34	3.9811E-04	141086.35
-5	-35	3.1623E-04	125743.34
-6	-36	2.5119E-04	112068.87
-7	-37	1.9953E-04	99881.49
-8	-38	1.5849E-04	89019.47
-9	-39	1.2589E-04	79338.69
-10	-40	1.0000E-04	70710.68
-11	-41	7.9433E-05	63020.96
-12	-42	6.3096E-05	56167.49
-13	-43	5.0119E-05	50059.33
-14	-44	3.9811E-05	44615.42
-15	-45	3.1623E-05	39763.54
-16	-46	2.5119E-05	35439.29
-17	-47	1.9953E-05	31585.3
-18	-48	1.5849E-05	28150.43
-19	-49	1.2589E-05	25089.1
-20	-50	1.0000E-05	22360.68
-21	-51	7.9433E-06	19928.98
-22	-52	6.3096E-06	17761.72
-23	-53	5.0119E-06	15830.15
-24	-54	3.9811E-06	14108.64
-25	-55	3.1623E-06	12574.33
-26	-56	2.5119E-06	11206.89
-27	-57	1.9953E-06	9988.15
-28	-58	1.5849E-06	8901.95
-29	-59	1.2589E-06	7933.87
-30	-60	1.0000E-06	7071.07
-31	-61	7.9433E-07	6302.1
-32	-62	6.3096E-07	5616.75
-33	-63	5.0119E-07	5005.93
-34	-64	3.9811E-07	4461.54
-35	-65	3.1623E-07	3976.35
-36	-66	2.5119E-07	3543.93
-37	-67	1.9953E-07	3158.53
-38	-68	1.5849E-07	2815.04
-39	-69	1.2589E-07	2508.91

dBm	dBw	Watts	uVolts (50Ω)
-40	-70	1.0000E-07	2236.07
-41	-71	7.9433E-08	1992.9
-42	-72	6.3096E-08	1776.17
-43	-73	5.0119E-08	1583.02
-44	-74	3.9811E-08	1410.86
-45	-75	3.1623E-08	1257.43
-46	-76	2.5119E-08	1120.69
-47	-77	1.9953E-08	998.82
-48	-78	1.5849E-08	890.2
-49	-79	1.2589E-08	793.39
-50	-80	1.0000E-08	707.11
-51	-81	7.9433E-09	630.21
-52	-82	6.3096E-09	561.68
-53	-83	5.0119E-09	500.59
-54	-84	3.9811E-09	446.15
-55	-85	3.1623E-09	397.64
-56	-86	2.5119E-09	354.39
-57	-87	1.9953E-09	315.85
-58	-88	1.5849E-09	281.5
-59	-89	1.2589E-09	250.89
-60	-90	1.0000E-09	223.61
-61	-91	7.9433E-10	199.29
-62	-92	6.3096E-10	177.62
-63	-93	5.0119E-10	158.3
-64	-94	3.9811E-10	141.09
-65	-95	3.1623E-10	125.74
-66	-96	2.5119E-10	112.07
-67	-97	1.9953E-10	99.88
-68	-98	1.5849E-10	89.02
-69	-99	1.2589E-10	79.34
-70	-100	1.0000E-10	70.71
-71	-101	7.9433E-11	63.02
-72	-102	6.3096E-11	56.17
-73	-103	5.0119E-11	50.06
-74	-104	3.9811E-11	44.62
-75	-105	3.1623E-11	39.76
-76	-106	2.5119E-11	35.44
-77	-107	1.9953E-11	31.59
-78	-108	1.5849E-11	28.15
-79	-109	1.2589E-11	25.09

Power Conversion Chart

dBm to dBw : Watts : Microvolts

dBm	dBw	Watts	uVolts (50Ω)
-80	-110	1.0000E-11	22.36
-81	-111	7.9433E-12	19.93
-82	-112	6.3096E-12	17.76
-83	-113	5.0119E-12	15.83
-84	-114	3.9811E-12	14.11
-85	-115	3.1623E-12	12.57
-86	-116	2.5119E-12	11.21
-87	-117	1.9953E-12	9.99
-88	-118	1.5849E-12	8.9
-89	-119	1.2589E-12	7.93
-90	-120	1.0000E-12	7.07
-91	-121	7.9433E-13	6.3
-92	-122	6.3096E-13	5.62
-93	-123	5.0119E-13	5.01
-94	-124	3.9811E-13	4.46
-95	-125	3.1623E-13	3.98
-96	-126	2.5119E-13	3.54
-97	-127	1.9953E-13	3.16
-98	-128	1.5849E-13	2.82
-99	-129	1.2589E-13	2.51
-100	-130	1.0000E-13	2.24
-101	-131	7.9433E-14	1.99
-102	-132	6.3096E-14	1.78
-103	-133	5.0119E-14	1.58
-104	-134	3.9811E-14	1.41
-105	-135	3.1623E-14	1.26
-106	-136	2.5119E-14	1.12
-107	-137	1.9953E-14	1
-108	-138	1.5849E-14	0.89
-109	-139	1.2589E-14	0.79
-110	-140	1.0000E-14	0.71
-111	-141	7.9433E-15	0.63
-112	-142	6.3096E-15	0.56
-113	-143	5.0119E-15	0.5
-114	-144	3.9811E-15	0.45
-115	-145	3.1623E-15	0.4
-116	-146	2.5119E-15	0.35
-117	-147	1.9953E-15	0.32
-118	-148	1.5849E-15	0.28
-119	-149	1.2589E-15	0.25

dBm	dBw	Watts	uVolts (50Ω)
-120	-150	1.0000E-15	0.22
-121	-151	7.9433E-16	0.2
-122	-152	6.3096E-16	0.18
-123	-153	5.0119E-16	0.16
-124	-154	3.9811E-16	0.14
-125	-155	3.1623E-16	0.13
-126	-156	2.5119E-16	0.11
-127	-157	1.9953E-16	0.1
-128	-158	1.5849E-16	0.09
-129	-159	1.2589E-16	0.08
-130	-160	1.0000E-16	0.07
-131	-161	7.9433E-17	0.06
-132	-162	6.3096E-17	0.06
-133	-163	5.0119E-17	0.05
-134	-164	3.9811E-17	0.05
-135	-165	3.1623E-17	0.04
-136	-166	2.5119E-17	0.04
-137	-167	1.9953E-17	0.03
-138	-168	1.5849E-17	0.03
-139	-169	1.2589E-17	0.03
-140	-170	1.0000E-17	0.02
-141	-171	7.9433E-18	0.02
-142	-172	6.3096E-18	0.02
-143	-173	5.0119E-18	0.02
-144	-174	3.9811E-18	0.01
-145	-175	3.1623E-18	0.01
-146	-176	2.5119E-18	0.01
-147	-177	1.9953E-18	0.01
-148	-178	1.5849E-18	0.01
-149	-179	1.2589E-18	0.01
-150	-180	1.0000E-18	0.01