RF Generator Troubleshooting

Q: What does it mean if the RF generator will not put out full power and the reflected power is nearly equal to forward power?

A: This generally means that the generator is in "reflected foldback." The generator is limiting its forward power output to protect itself against excessive reflected power. For Comdel generators, this foldback occurs when the reflected power reaches about 20% of the full rated power of the generator. This condition is seldom the fault of the RF generator. The problem might lie in the coax, the matching network, or a short of open in the RF chain after the match. In plasma applications, any condition that prevents the striking of plasma will result in high reflected power.

Q: What if reflected power is higher than desired, but not nearly as high as forward power?

A: Under these conditions, some energy is being delivered to the load, but the impedance matching mechanism of the system is not able to match the load well enough. If the generator is fixed frequency, then the fault lies elsewhere. If the generator adjusts its frequency to accomplish impedance matching, then this may be suspect, but so might the impedance matching network that works with the generator. Other causes include chamber conditions resulting in plasma impedance outside the range of the matching network.

Q: What does the blinking red light on the right front of my CX Series RF generator mean?

A: This means the safety interlock loop is not satisfied. Internal to the generator there are cover interlocks and an interlock switch associated with the RF output(s) that is actuated by the cover that goes over the coax cable connection. In addition to these there, are two connector pins on the external interface that must be connected together in order to satisfy the interlock chain. Typically these two pins are connected together using switches on associated external parts, such as the matching network cover or plasma chamber.

Q: What should we do if the lights for the generator and display will not come on?

A: First, check to see if breaker on the back of the generator is on (circuit breaker should be in the up position). Next, verify that there is AC power to the generator (verify AC power with a voltage meter). If these conditions have been verified and there are still no lights lit and no display present, the generator may need to be replaced. Please contact us.

Q: What do I need to know about troubleshooting my RF power supply?

Test Equipment for Troubleshooting:

To properly test your supply, you need a standard portable digital multimeter (DMM), a power-SWR meter, and a dummy load.

Multimeter: It measures AC/DC voltages, amperage, and ohm resistance of pots and pickups. It is used to measure line voltage and, when set as an ohm meter, it can be used to check the coax cable.

Power-SWR Meter: Our generators have built-in power meters that show forward and reverse power, but for setting up and testing power supplies, an external meter is useful.

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RF Generator Troubleshooting

Dummy Load: Dummy loads are necessary for troubleshooting the generator at medium and high power levels. Commercial dummy loads are available with a 50-ohm resistive, non-inductive impedance, with power levels ranging from a few hundred to many thousands of watts. The dummy load is usually connected to the output of the RF generator with a short 50-ohm coaxial cable and allows you to put maximum power into a standard load while making tests on the generator. When testing RF generators using impedance-matching networks, a dummy load that more accurately represents the load in the system is highly desirable.

Additional equipment:

Oscilloscope: This is used to observe the signals from the crystal oscillator through the various driver, buffer, and power amplifier stages. The scope will show any signal distortion, noise, or other characteristics that cannot be detected with a voltmeter.

Frequency Counter: The primary use of this piece of equipment is to check the operational frequency of the RF generator and to verify that the crystal oscillator is on frequency. RF generators are regulated by the FCC and must operate on specific frequencies within a given tolerance range. If the actual frequency deviates too much, adjustments may be necessary. Frequency adjustments are made only after the equipment has warmed up for at least an hour—it's important that the generator be at a stable normal temperature before adjusting the frequency.

Spectrum Analyzer: This Oscilloscope-like equipment is useful in diagnosing unusual troubles in a generator that may be related to distortion and harmonics or spurious signals. Most spectrum analyzers are used in RF communications systems where they can show the sidebands developed during modulation as well as harmonic distortion and for detecting and isolating interference.

RFI-EMI Tester: This test equipment is a highly sensitive radio receiver designed to detect stray RF radiation, including harmonics and intermodulation products. The more sophisticated test sets incorporate a spectrum analyzer.

Field Strength Meter: This is a simple radio receiver used to measure the amount of signal radiated from an RF source.

Troubleshooting Safety Tips:

1. Remove all jewelry before working on RF generators and related equipment. Metal jewelry can cause serious harm or even death when you are working on high-voltage RF equipment.

2. To minimize accidentally touching a voltage source when working inside the equipment on power supplies or high-voltage connections, use only one hand and keep your other hand in your pocket.

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RF Generator Troubleshooting

Troubleshooting Safety Tips:

3. Do not disable any equipment interlocks. With power removed, you can usually troubleshoot in safety. The low voltage (24 V) safety interlock circuit is designed to disable the unit in the event of an interlock fault condition. Low voltage power for the interlock circuit is supplied by a step down transformer located inside the unit. This transformer is designed to provide safe low-voltage operation and provide isolation from the main AC line.

4. To avoid an accidental shock, keep your clothes and work area free of water or moisture.

5. To prevent electrical shock and/or RF burns, never operate equipment with the covers removed. Never operate without an appropriate cable connected between the RF output connector on the rear panel and the load.

6. Equipment must be bonded to Protective Earth (safety ground) prior to operating the unit. Safety ground connection must be made at the unit's rear panel designated 1/4"- 20 threaded ground stud. The ground wire should be a #14 awg or equivalent (minimum) green/yellow lead.

7. Prior to performing system maintenance, repair or other service operations, the generator must be locked out and tagged out to prevent accidentally energizing the system. First disconnect AC input power to the generator, then mount a suitable "Clamshell" type lockout device to the AC input plug such as a Hubbell # HLD2 or equivalent. Follow all manufacturers' directions for the lockout device.

Troubleshooting First Steps:

WARNING: Equipment must be installed, operated and serviced only by trained, qualified persons.

CAUTION: Breaking the seal or removing the warranty decal from any unit will void the warranty. If internal damage is suspected, contact us for assistance.

1. If a problem with the generator has been identified, verify it by attempting to duplicate the problem.

2. Inspect cables and connectors.

3. Check for the correct settings of front panel controls, observe any meter readings or display readouts, and re-enter commands from equipment connected to a personal computer or terminal. For instance, zero forward power and maximum reflected power might indicate an open coax cable between the generator and matching unit, or a bad matching unit.

4. One of the most obvious problems is simply lack of power to the equipment. Check circuit breakers and reset, if necessary. Verify that there are no bad fuses. If a fuse was blown, replace it with one of the same value and type. Then recheck the equipment.

5. If the system is still malfunctioning, in most cases, the next step should be to replace the generator with a functioning spare to get the system back in operation.

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RF Generator Troubleshooting

General Questions

Q: What's S-Technology?

A: S-Technology is a patented, unique amplifier design that makes the gain of the power amplifiers in Comdel "S" generators constant rather than dependent upon load conditions. As plasma impedance changes, especially the large change that occurs at the instant of plasma ignition, non "S" generators may display erratic power gain characteristics that result in amplitude modulation of the RF envelope. This modulation can cause matching networks to malfunction completely or, more subtly, can shorten matching network life. This is the reason that Comdel does not supply matching networks to be used with non "S" generators.

Q: Why is the 13.56 MHz frequency used for RF plasma applications?

A: 13.56 MHz is one of several I.S.M. frequencies mandated by the FCC. These are frequencies set aside for industrial, scientific, and medical purposes and have relaxed emissions limitations because they are so positioned in the radio wave spectrum as to not interfere with safety, emergency, and military communications. It just happens that this particular ISM frequency has the most plasma research historical data.

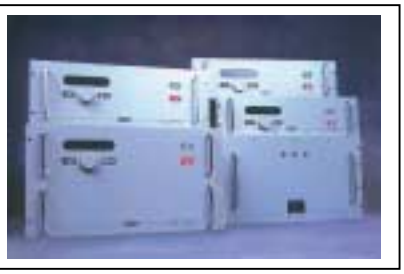
Q: What's the difference between a linear and a non-linear amplifier?

A: A linear amplifier is one in which the output current is directly proportional to the voltage input. Linear amplifiers do not distort the signal or cause harmonics to be introduced. A class A amplifier is an example of a linear amplifier. A nonlinear amplifier is one that does not operate over the linear operating region of the transistor or tube. Instead, the device is used primarily as a switch to turn the current off and on. Nonlinear amplifiers generate pulses or square waves at the frequency of operation.

CX600 RF Generator

CX1200 RF Generator

Matching Networks



CX Series RF Generators

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RF Generator Troubleshooting

General Tips*:

Forward Power:

The forward power is material dependent, for metal such as Au, 50 Watt or less will be good. If higher power is used for metal target, the target may crack. For semiconductor and insulator targets, higher power is required but be careful when apply more than 100 Watt (<100 Watt is recommended first) - extreme caution must be taken - contact fellow scientists if necessary.

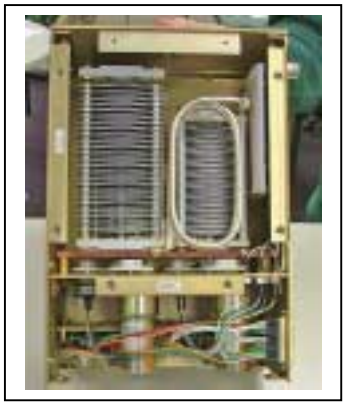
Impedance Matching:

The impedance matching is done in integral steps while monitoring the forward, and the reflected power. First try to get the desired forward power then try to minimize the reflected power - one might need to go back to the forward adjustment since the forward and the reflected reading are mutually dependent.

During this sputtering process, one may have to continue checking the reflected power and may have to do small adjustment again. This is more common for non-metal target.

Various views of an automatic matching network (CPM-1000) are shown below.

* Above tips are for general guidelines only. Please use your experience and/or consult fellow scientists for each application. Vin Karola assumes no liability for any event that may cause any damage to any equipment/material.



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