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| | **Model PB3 RF Power System Plasma Impedance Matching Notes** | Rev. date | Rev. 0 |

# Product: Model PB3 13.56 MHz

# Subject: Plasma Impedance matching problems & Solutions

This technical bulletin addresses typical problems encountered when commissioning the PB3 RF plasma power system. It is assumed that the RF generator section is completely operational as delivered from the factory.

This may be verified by connecting the RF generator's output connector to a *known good* 12' long coaxial cable and then to a typical 50 ohm resistive termination (dummy load) of the proper power rating. Power up the unit and run the RF output power control up to full power. Note the reflected power reading – it should remain low – approximately 3% of forward power or lower. In the event that the maximum power delivered by the RF generator cannot be reached or the reflected power is higher than 3% then there may be a problem with the RF generator. Please contact the factory before continuing as there may be problems with the RF generator.

**Matching Network Tap Settings**

The typical Model PB3 system is equipped with a wide range impedance matching network including a tapped series inductor and (in some models, factory installed) additional fixed shunt capacitors. The tap adjustment and the additional capacitors enable the user to simply follow the owner's manual directions to properly set up the matching network.

**High impedance (physically small) plasma loads**

First one must determine the anticipated plasma load impedance or more casually, understand how to preset the proper values of inductance and capacitance. The rules of thumb are: if the physical size of the load is small (i.e. a 1" or 2" diameter magnetron sputtering cathode), then the impedance is known to be fairly high. To tune this type of plasma load the maximum inductance (on the series inductor) setting should be used. Please note that some manufacturer's cathode products will require an inductance greater than that of the standard PB3. If this is the case, then the user must prepare his own or purchase one through Manitou Systems. The symptom of not enough inductance is the TUNE control wants to be set to its maximum position during the tuning process.

If the plasma load is physically large – such as a 8" diameter magnetron cathode or a large parallel plate plasma reactor, then the impedance is typically low. Low impedances usually require a near maximum LOAD capacitor setting. In the event that the LOAD control wants to be set to its maximum position during the tuning process, this is an indication that the RF tuning circuit does not have enough load capacitance and an additional fixed value is required. We typically install these capacitors in increments of 100 or 200pF.

**Rules Of Thumb**

- **If the plasma electrode is small**, then the plasma impedance is considered to be high. The tap setting on the series inductor will need to be placed on a high inductance (maximum turns) setting. In some cases the standard coil may need to be replaced with a coil that has more turns or simply adding a 2nd coil to effectively increase the inductance.

- **If the plasma electrode is large**, then the plasma impedance is considered to be low. The tap setting on the series inductor will need to be placed on a low inductance (minimum turns) setting.

- **If the plasma electrode is large**, the shunt or LOAD capacitor will need to be set to a high capacitance value. In some cases, additional fixed shunt capacitance may need to be added to enable the unit to properly tune the plasma load.

- **If a coaxial cable is used to connect the plasma load to the matching network**, the length of the cable (or parallel cables in some cases) determines the Load capacitor setting or if additional capacitance is needed. Longer cables or dual parallel cables require higher capacitance.

- **If the TUNE Capacitor wants to match at a very low value**, you need to reduce the series inductance to raise the TUNE capacitor match point.

- **If the SHUNT Capacitor wants to match at a very high or maximum value**, you need to increase the shunt capacitance by installing additional fixed capacitors.

**Other Strange Matching Problems**

Some RF power system installations exhibit strange and unexplainable conditions. We will assume that the matching network tunes normally – this is defined as both TUNE & LOAD capacitors are able to be individually nulled however the reflected power display still shows a value that is higher than 1% of the forward power value. This condition may be caused by the reflected power sensor detecting harmonic energy. Harmonics are typically generated in a plasma discharge however, the matching network circuit is considered to be a good low pass filter so in most applications these harmonics never reach the RF generator. To cure this problem you will need to install a low pass filter module directly at the matching network's input connector.

Using the scenario as described above, the inability to tune out the reflected power can be remedied by changing the length of the coaxial cable connecting the RF generator output to the matching network input. The typical Model PB3 has an internal 13.56MHz ¼ wavelength cable already installed. You can try adding a 3' > 4' section to see if the tuning problem disappears. If not, then add a complete ¼ wavelength in series with the existing cable. For a PB3 system you will need a type RF 58 cable with a male BNC on one end and a female BNC on the other side (or 2 male connectors with a double female adapter.

Check back to this Application Note as it will be updated in the future.

References: *(All reference material available from the Manitou Systems website download page.)*


- Model PB3 Owner's Manual
- Model MTK Owner's Manual
- Converting the PB3 Impedance Matching Network from "L" > "PI"
- Using Long Coaxial Cables To Connect The Impedance Matching Network To The Plasma Load