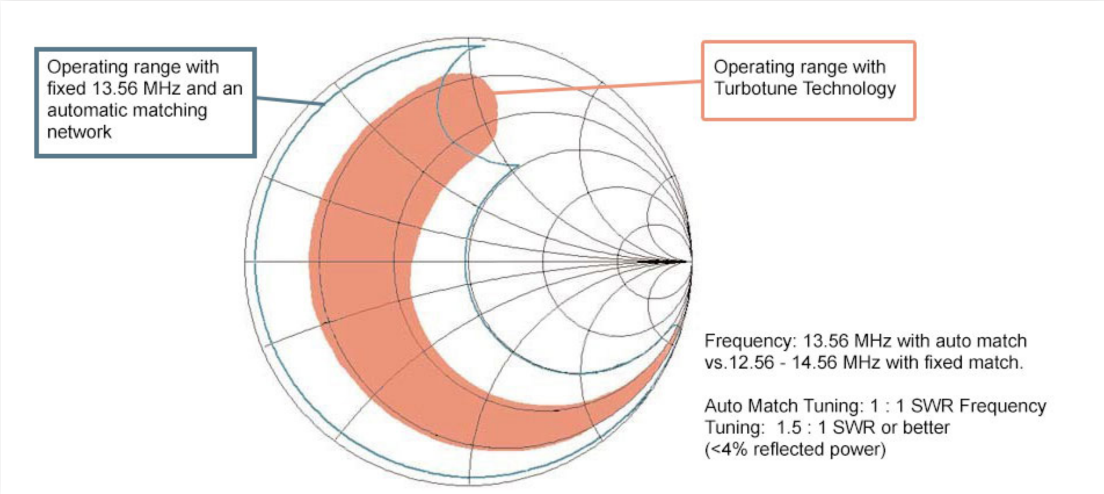
TECHNICAL ARTICLE

OPTIONAL FREQUENCY AGILE TUNING

As cost and reliability become ever greater considerations and as plasma processing systems become more process specific presenting a narrower range of impedances to the RF delivery system, frequency tuning is becoming more accepted at all frequency ranges in place of the relatively expensive automatic matching network. By utilizing a carefully designed fixed match, a small shift in generator frequency (maybe ±10%) can transform the load similar to moving one of the variable capacitors in an automatic matching network. This method may not completely eliminate reflected power so the RF generator is often controlled on “delivered power” rather than “forward power.” This approach, sometimes called “load leveling,” causes the generator to put out additional power to make up for the reflected power not delivered to the load.



Two methods of controlling frequency exist. One is a phase detector as typically used in automatic matching networks, but this time installed in the RF generator. The other is a "tuning algorithm," a microprocessor controlling the frequency to minimize reflected power. Each method has its pros and cons.

The phase detector is fast and reliable and naturally follows the resonance of the load, but phase detector applications are load specific. The fixed match must be carefully designed to fit the type of load driven so that there is only one resonant frequency and so this resonance is close to 50 ohms. Also, because the transmission line is between the phases detector and the match, it is part of the circuit that the phase detector observes, so the length of transmission line must be known to the match designer and must not be changed significantly in the field. Probably the greatest advantage to the phase detector approach to frequency tuning is that the frequency sweeps almost instantaneously to resonance with no frequency overshoot.

Tuning algorithms require less homework in the match design, and are not cable length dependant. Recent improvements in both hardware and software associated with tuning algorithms allow tuning step sizes to be very small without sacrificing speed. Thanks to these advances this technology now rivals the phase detector in speed and reliability.

In addition to these distinctions in frequency tuning methodology, the tuning algorithm approach can be broken into two subcategories. These are the Voltage Controlled Oscillator (VCO) controlled by an analog voltage which is in turn controlled by a microprocessor via a digital-analog converter, and the Direct Digital Frequency Synthesizer (DDS), an integrated circuit that generates a variable frequency output controlled by a digital input. Again, each has its advantages.

Because the VCO is controlled by an analog voltage that changes over time, it cannot create jumps in frequency. This can be an advantage in high Q situations that might suffer snuff-out or voltage spikes (theorized to cause on-wafer device damage) if large changes in frequency happen instantaneously. In lower Q situations, however, the ability to jump from one frequency to another might be a benefit in terms of tuning speed. The DDS approach also lends itself to preprogrammed frequency tuning which can follow an empirically derived set of frequency steps to accomplish plasma ignition and stabilization prior to employing a standard tuning algorithm.

XP Power provides all of these technologies and our engineers have years of experience determining if frequency tuning is appropriate for a given RF delivery application and which method is the best approach.