1.14 Tuning Stubs as an Aid to Coupling RF Energy to Electrodeless Discharge Lamps*†

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Efficient coupling of rf energy to an rf excited electrodeless discharge lamp is an important procedure frequently overlooked by spectroscopists. If incorrect coupling of the rf energy (via the usual coaxial transmission line) occurs, several undesirable conditions result: (1) The energy transfer is inefficient and the coaxial transmission line will dissipate some of the energy as heat, and (2) some of the rf energy will be reflected back to the rf generator with possible damage to the generator, particularly the magnetron oscillator tube.

Most efficient transfer of rf energy from an rf generator to a load will occur when the output impedance of the generator, the characteristic impedance of the coaxial cable, and the load impedance are equal (matched). In the case of the electrodeless discharge lamp the load includes the antenna or microwave cavity and the lamp. When all impedances are matched, there are no standing waves on the coaxial transmission line and the line is said to be flat.

Matching the rf generator to a coaxial transmission line is not a problem since most generators are constructed with a 50-Ω output impedance and several varieties of coaxial cables are available with a 50-Ω

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characteristic impedance. Antennas and microwave cavities can be constructed to produce a load impedance of approximately 50 Ω; however, when any object is placed in the rf field close to the antenna or in a cavity the impedance is changed, sometimes radically. Standing waves thus are established in the line to reflect power back to the rf generator and lower the efficiency of energy transfer.

In our research dealing with microwave excited electrodeless discharge lamps as atomic absorption spectroscopy sources we found the problem of standing waves (mismatch between the line and the load) on the coaxial transmission cable to be adversely affected by a number of factors. These included such items as size of the discharge lamp, nature of the fill gas, nature of the active substance in the lamp (metal, metal salt, etc.), temperature of the discharge tube, use of jacketing materials, intensity of the discharge, and probably others. It therefore became important to have independent means for minimizing the power reflected back to the rf generator.

Since the impedance of the transmission line is fixed as is that of the load, an impedance matching transformer between the coaxial line and the load is required. At low rf frequencies impedance matching can be accomplished using an inductance-capacitance network. At microwave frequencies (in our case 2450 MHz) tuning stubs are used and are more efficient. Also necessary is some device which indicates when a condition of minimum reflected power is obtained. A standing wave ratio meter (or a reflected power meter) should be used for this purpose. Such meters are built into some rf generator units and can also be purchased separately.

The wavelength corresponding to 2450 MHz is small enough to permit the construction of a one-fourth to one wavelength tuning stub or stubs for impedance matching. The design of shorted tuning stubs that meets these requirements is described herein.