4.3 HIGH POWER DUPLEXERS

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The most difficult problem facing the duplexer designer today is that of switching ever increasing powers while still maintaining short recovery time and low loss in the receiver circuit. A thorough knowledge of microwave circuits and gaseous discharge phenomena is essential.

The circuits used can be divided into three types; (1) the branching duplexer with its TR and ATR cavities, (2) the balanced duplexer with broadband pass or stop structures, and (3) the unity coupler duplexer. These three types are also given in the order of increasing bandwidth of the system in which they are generally used. The power handling limit of the switching tube is determined by the r.f. current which it must carry. For similar designs the Q and the power dissipated in the TR structure are inversely proportional to one another. Thus it is a cardinal principle of high power duplexer design to use as high Q structures as the system requirements will permit. For narrow band systems (<0.5%), because of the insertion loss requirements, the loaded Q is usually determined by the unloaded Q of the cavities used. In this case it can be shown that any of the first two types of duplexers will handle the same power for a given insertion loss so that simplicity usually dictates a simple TR-ATR cavity type duplexer.

For systems with medium instantaneous bandwidth (1 to 15%) the necessity of making the low level insertion loss independent of transmitter impedance over the band dictates the use of a balanced structure of type (2) above. An analysis of the Q bandwidth products achievable with TR and ATR balanced duplexers shows that for the same instantaneous bandwidth the ATR balanced duplexer can handle twice the power of the TR balanced duplexer.

High power microwave gas switching tubes have evolved along two lines, the encapsulated window and the folded cylinder. In both the r.f. current is capacitively coupled into the discharge which takes place between two dielectric surfaces. Recent measurements have shown that at low current densities the electric field necessary to sustain the discharge is constant and the same as that for the positive column of a dc discharge under the same conditions. The sustaining field increases at power levels above that at which the skin depth in the plasma is equal to the spacing in the tube. At very high power levels collisions of electrons with positive ions cause the electron conductivity to become constant. Then the electric field increases in direct proportion to the current. With this maximum value of conductivity one can estimate the power handling capacity of various switching tubes using various methods of cooling.

A graph of firing voltage as a function of the appropriate dimensionless parameters may be measured experimentally and used to determine a design which will give easy firing. When pure inert gases or metal vapors are used the recovery is controlled by diffusion or recombination. Lowest arc loss is obtained at low pressures where the recovery is diffusion controlled. Recovery time is easily calculated.

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