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TCA Microvave Interferometer

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A 2mm, 140 GHz microwave interferometer is a reliable off the shelf density diagnostic that requires a minimum of development and custom tailoring for any particular configuration. The custom work would involve the mounting and control of movable antennas and vacuum feedthroughs. This problem could probably be solved by the use of flexible X band or Ku band waveguide driven in an overmoded state.

For a single channel fixed position interferometer the mounting and control of the antenna is a minor problem. A simple interferometer is shown in figure 1. The components and approximate costs are listed in Table I. There are two options for the source - a reflex klystron or an extended interaction oscillator (EIO). The klystron is limited to 100 milliwatts output power, has a lifetime of 150 hours, and costs Fr. 17'000.--. The laboratory has a klystron power supply. The EIO has a power output of at least 3 watts, a lifetime of 1000 hours and costs Fr. 26'000.--. The EIO requires an expensive power supply and cooling unit which costs an additional Fr. 36'000.--. A figure of merit for the two sources is the cost/watt-hr. The klystron costs Fr. 388/watt-hr and the EIO costs Fr. 21/watt-hr. The EIO has adequate power for at least 4 simultaneous channels. It can also be ordered with up to 20 watts of power for more channels or microwave scattering experiments. A 200 watts pulsed option is also available. The laboratory has an adequate magnetron pulse generator which can be adapted to the EIO for pulsed operation if desired.

The recommended source is the 3 watt EIO. The cost of a single channel fixed position interferometer is Fr. 110'000.--.

The configuration for a multichannel interferometer is very similar to figure 1. Since a single launch antenna can be used, the increased cost is not as large as one might have thought. The list of components is given in Table II. The circular horn antenna has a good uniform radiation pattern with a 3 dB beamwidth of 70°. It could be theoretically treated as a point source radiator. The recommended source for the four channel fixed antenna system is the 3 watt EIO. The total cost for the system is Fr. 185'000.--.

The increased cost for a moveable position single beam or multiple beam interferometer is not in the microwave components, but in the design and machining of the antenna control system. The laboratory could presumably benefit from designs already made at other laboratories. The use of flexible waveguides might create a problem with the path length in the event of mechanical vibration. For this reason it would be better to have many receiving antennas in a fixed flange and only a few interferometer channels which could be moved from antenna to antenna. A large horn antenna which could uniformly illuminate the plasma could also be better than the point source antenna.

The problem of channel interference has been solved by other laboratories by using multiple launch antennas with varying path lengths and frequency sweeping the source. If this becomes necessary the rough estimate for the additional cost for the four channel at a time, ten antenna system would be Fr. 20'000.-- For two channels at a time the estimate for the additional cost would be Fr. 12'000.--

If one wanted to economize on the four channel interferometer, the information obtained by the received power directional coupler is of minimal value and can always be obtained at the hybrid junction with another shot. The attenuation of the microwaves is very small so that the received power should remain constant. In this case a savings of Fr. 20'000.-- would be made and the total price for the four channel interferometer would be Fr. 165'000.--. If one wanted ten fixed antennas with four channels at one time capability the total cost would be Fr. 176'000.--. It would take three shots to get a complete profile. (One would always repeat the center measurement for an internal check).

One could further economize with a two channel interferometer with ten antennas. It would then require nine shots for a density profile. The total cost for this option would be Fr. 145'000.--.

It is recommended that the laboratory pursue the last option, i.e., a two channel interferometer with ten antennas in a fixed flange. If money and convenience dictate the system can always be upgraded to more channels.

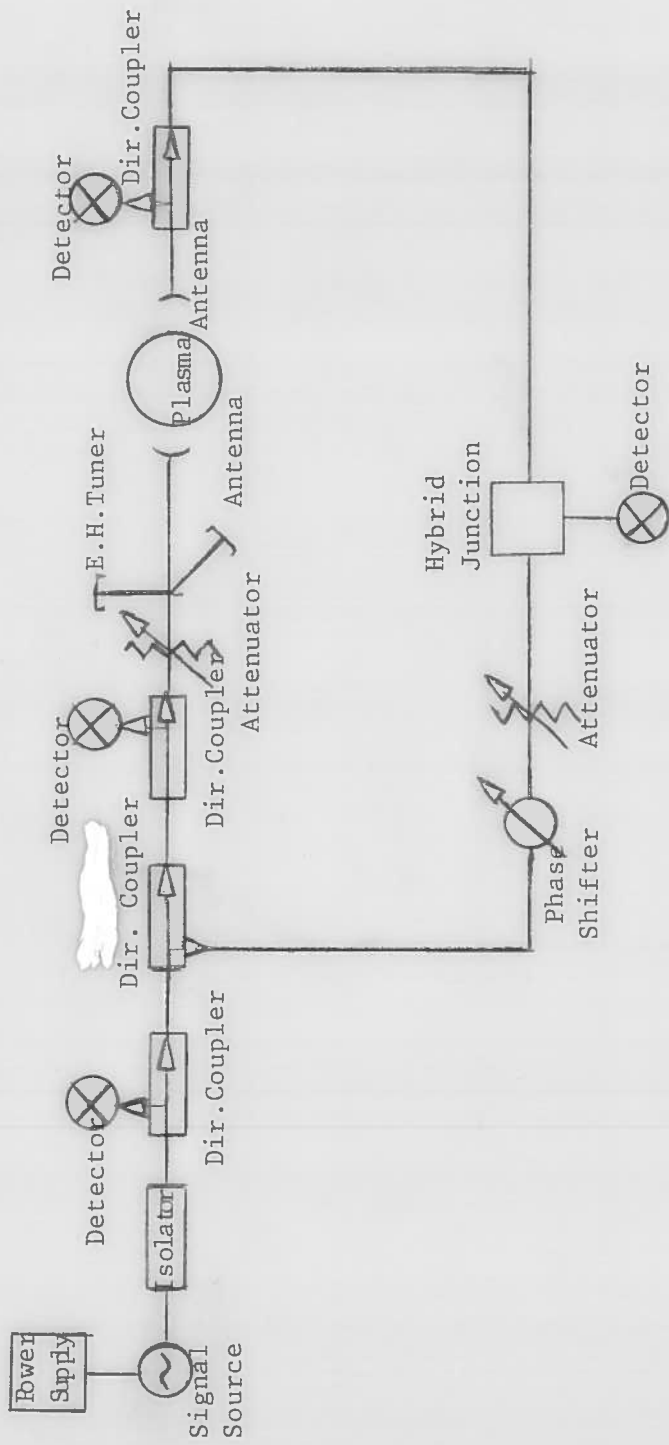


Figure 1. Microwave Interferometer

T A B L E I

SINGLE CHANNEL INTERFEROMETER

<u>Description</u>	<u>Price</u>
Source (EIO)	Fr. 26'000.--
Power Supply	Fr. 36'000.--
Isolator	Fr. 5'030.--
Directional Couplers (4)	Fr. 11'060.--
Attenuators (2)	Fr. 8'720.--
Phase Shifter	Fr. 2'600.--
E.H. Tuner	Fr. 2'310.--
Hybrid Junction	Fr. 3'770.--
Termination Load	Fr. 435.--
Horn Antennas (2)	Fr. 3'020.--
Detectors (4)	Fr. 4'240.--
Sliding Shorts (4)	Fr. 4'360.--
Waveguide straight sections and bends	Fr. 2'455.--
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Total	Fr. 110'000.--
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T A B L E I I

FOUR CHANNEL INTERFEROMETER

<u>Description</u>	<u>Price</u>
Source (EIO)	Fr. 26'000.--
Power Supply	Fr. 36'000.--
Isolator	Fr. 5'030.--
Power Splitter	Fr. 10'000.--
Directional Couplers (7)	Fr. 19'355.--
Attenuators (5)	Fr. 21'800.--
Phase Shifters (4)	Fr. 10'400.--
E.H. Tuner	Fr. 2'310.--
Hybrid Junctions (4)	Fr. 15'080.--
Termination Loads (4)	Fr. 1'740.--
Horn Antennas (4)	Fr. 6'040.--
Circular Horn Antenna (1)	Fr. 3'100.--
Detectors (10)	Fr. 10'600.--
Sliding Shorts (10)	Fr. 10'900.--
Waveguide straight sections and bends	Fr. 6'645.--
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Total	Fr. 185'000.--
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