Design of Telescopic Stub Tuner of 1 5/8” Transmission Line

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Abstract. Stub tuners are integral part of matching network of plasma impedance matching with high power RF generator for maximum transfer of power. Here at IPR we are using various types of stub tuners along with phase shifters for matching the plasma impedance with that of high power RF generator. Here we present the design details of indigenously developed telescopic type stub tuner. In the conventional type stub tuners the overall length of the stub tuner system is more than double the length of matching length. This is because of the movement of plunger and the whole length of the driving rods has to come out of the stub. Hence the overall stub length is more than double the length required for matching. In Telescopic design, during movement of the rods, the single rod does not come out but is adjusted within the other. This makes the system less heavier and reduces the overall cost of the stub.

1. Introduction
Stub tuners are used in high power RF systems for matching of load impedance with the rf generator impedance for maximum transfer of the power. In tokamak experiments the stubs are used for matching plasma load impedance with generator impedance in the power range of few hundred kilowatts to megawatt level. Normally the frequency of operation lies in the range of 10-100 MHz. However in case of few applications although the power may be few hundreds of kilowatts, the frequency of operation may be different. In one of the applications for which the telescopic stub is designed, is in the range of 350 MHz. In the conventional type stub tuners, the overall length of stub tuner is more than double the length of matching stub. This is because of the length of driving rods has to come out of the stub. In telescopic design, during movement of rods, the single rod does not come out but is adjusted within the other. This makes the system less heavier and reduces the overall cost of the stub.

2. Design parameters
The stub dimensions are selected on the basis of power handling capability as well as the frequency of operation and is of 1 5/8” size. It is to be operated at 350 MHz and 6 kW of power for a particular application. The movable length is selected slightly more than the required length and is
approximately by 500 mm. The moving speed of the plunger is 2 mm/sec or more. The stub is designed to have 50-ohm characteristic impedance.

3. Mechanical Design
The system is made of 1 5/8" size EIA standard transmission line. Inner and outer conductors are of ETP copper with 99.95% purity. The plunger is also of ETP copper with 99.95% purity. Plunger slides between the inner and outer conductors with the help of finger contacts. Finger contacts are made up of Beryllium copper and are able to sustain required short circuit current. The inner conductor joints are made up of brass. The system is motorized and is having a stepper motor for better accuracy. Stepper motors can give rotational accuracies even up to 1º-2º and hence can respond to minute changes in impedance by which the accuracy improves. The system has pressurisation facility upto 3 bars to avoid arcing/breakdown due to high rf voltages. Figure 1 shows the schematic of the developed telescopic stub tuner.

![Figure 1. The schematic of telescopic stub tuner of 1 5/8" size.](image)

4. RF Design
The stub tuner is to be used at 350 MHz. For providing full range of matching the stub length should be at least \( \frac{\lambda}{2} \). The wavelength at 350 MHz is 850 mm, so the stub length should be 425 mm or more. The length has been kept 500 mm to take into considerations other mechanical constraints like length of the tee and inner conductor joints etc. The outer diameter of inner conductor is 16.8 mm while the inner diameter of outer conductor is 38.8 mm, so the stub tuner is of 50 ohm characteristics impedance.

5. Results
The system has been fabricated and tested by VNA with open load. The test result of return loss at slightly higher frequency is shown in Figure 2. The result shows return loss better than -45 dB which indicates that the developed telescopic stub tuner can be used successfully for matching at 350 MHz.
Figure 2. Test Results of Telescopic stub tuner of 1 5/8”.

6. Conclusion
The fabricated stub tuner works well in the required frequency range with acceptable return loss. In the initial stages the stub tuner is operated manually. In the next phase the motorized operation will be carried out.