



Theme Name	Impedance matching tuners (automatic and manual) for microwave circuit
Organization Name	Plasma Applications, Inc.
Technical field	IT Manufacturing
Overview	
<p>Tuners for impedance matching can decrease the reflected microwave power from external load in microwave circuits so that it is important to effectively use the microwave input power. In particular, for loads such as microwave plasma where the impedance fluctuates easily, it is necessary to continuously perform impedance matching. In this lab, compact automatic matching tuners (Auto Tuner) have been developed to realize impedance matching in a short time. Compact and lightweight manual matching tuners for 400MHz, 915MHz, 2.45GHz and 5.8GHz have been commercialized. All of these products have been widely used as convenient tools. These products are available not only for plasma generation circuits, but also for microwave applications such as microwave heating reactors. We welcome such companies that are willing to develop business models by deploying these products.</p>	
Simplified	
<p>Microwave impedance tuners (Automatic / manual)</p> <ul style="list-style-type: none"> • Manual tuner with double slug structure for easy handling (unit: mm. The figure below is for the 2.45GHz manual tuner). • Automatic tuner (auto tuner) that can perform quick and automatic impedance matching condition. <p>Both are in the ISM band and widely available.</p>	
<p style="text-align: center;">MDS-2450</p>	



(Feature)

- For loads such as microwave plasma whose impedance is likely to fluctuate, auto tuner can automatically make impedance matching.
 - Customize tuning speed and response time.
- Implement impedance matching in a short time (usually less than a few seconds).
- The auto tuner has automatic mode and manual mode and can be selectable.
 - The auto tuner can monitor the reflected power from the external loads.
 - Teflon slugs with high sliding ability and durability are used for the both matching tuners.

Matching condition can be sustained stably even when used continuously.

(Application areas)

Both tuners can handle such loads as microwave plasma systems or other loads with impedance fluctuation.

Both tuners are considered as an essentially important equipment for the microwave circuits.

Auto Tuner is rather difficult to make initial setting. If insufficient settings are used, Auto Tuner will give unpleasant results. In such cases, there are optional supports with charge, which will make optimized initial setting under the same conditions as users are using.

Background

Impedance matching with external loads is also essentially important in microwave circuits, as in general AC electric circuits.

If impedance mismatch occurs, microwave reflection from the load occurs, which not only lowers efficiency, but also may cause equipment burnout in the worst case.

When the plasma is generated using microwaves, the impedance is greatly changed just after the plasma generation. Also, variations of impedance are caused by various factors such as plasma instability even after plasma generation.

In many cases, stubs are often used to match impedance in microwave circuits. These are made by a short branches (stubs) on the microwave transmission line or microwave waveguide that adjust the insertion depth of the stubs into the microwave transmission line to align the impedance.

A three-stub matching tuner using three stubs is often used. In this case, at first two stubs adjustments are performed, then the remaining one is



adjusted, and should be followed the first two adjustments. The adjustment procedure becomes complicated so that the impedance matching in a short time was difficult. Thus, the impedance matching is a big problem in the use of microwave plasma. Therefore the impedance matching tuners with compact size and easier handling, especially auto tuner have been required.

Plasma Applications Co., Ltd. is a university venture established by Professor Masashi Kando of Shizuoka University (formerly) Electronic Science Research Institute.

Technical Content

The Impedance auto-matching device (hereafter called as “Auto Tuner”) of Plasma Applications is equipped with an impedance matching tuner of a double-slug structure, and the slug positions are adjusted by stepping motor under the control of software, which can be connected to PC if necessary. Moreover, the impedance matching unit is also provided as an independent product as Double slug tuner (hereafter called as “DST”).

The Auto Tuner has the following characteristics.

- The two slugs are motor driven to minimize reflected power.
- Impedance matching can also be automated on load that is likely to change impedance such as a microwave plasma, where Auto Tuner initial setting can correspond to the complicated procedures on several modes of external loads and is allowed to control Auto Tuner operation by PC.
- The tuning speed and response time can be customized.
- The Auto Tuner is rather compact as a whole.
- Impedance matching is achieved in a short time (usually less than a few seconds).
- Automatic mode and manual mode can be selected.

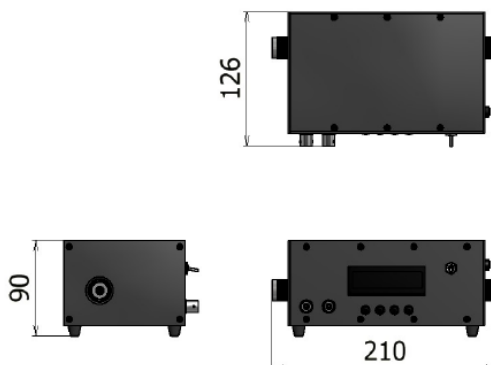
Note that manual mode is convenient for presets when impedance is predicted beforehand.

The specification of products are as follows:

1. Auto Tuner ADS - 2450 (for 2.45 GHz)



The product size (unit: mm) is compact as follows,

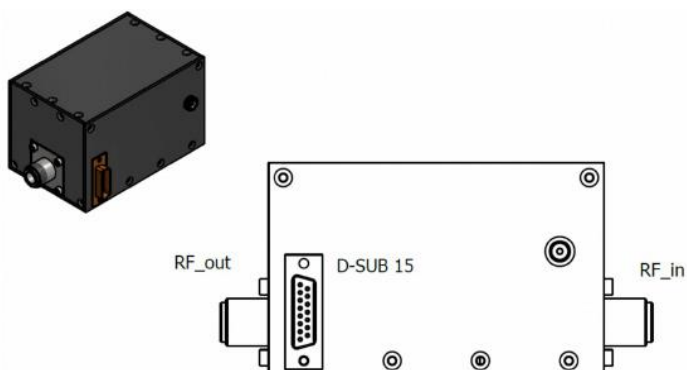


Main Specifications

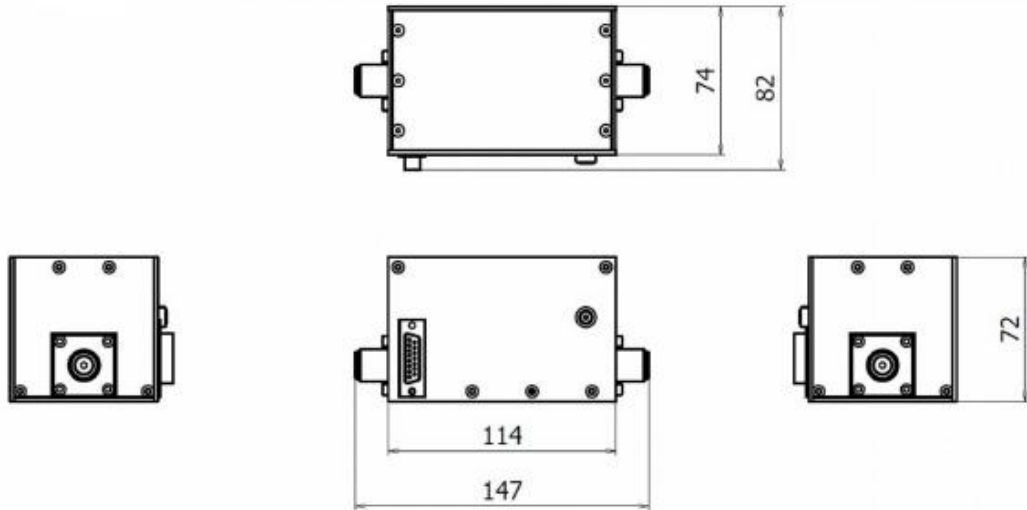
Item	specifications
Microwave power maximum	200W
Microwave frequency range	2GHz-3GHz
Insertion loss	0.17dB
Maximum controllable SWR	20
Input connector	N type (plug or jack)
Output connector	N type (plug or jack)
Connector for reflected power monitor	BNC (jack)
Power supply	AC100-240V

(We are also investigating higher power microwave matching devices)

2. Auto Tuner ADS - 5800 (for 5.8 GHz)



This product is more compact than that for 2.45 GHz.



(in mm)

Main Specifications

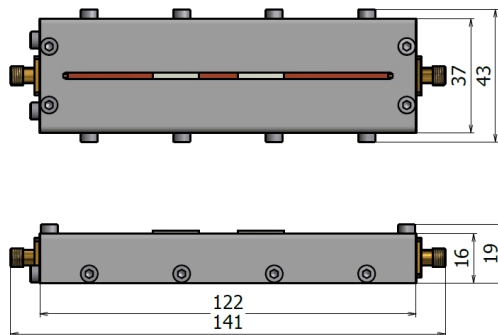
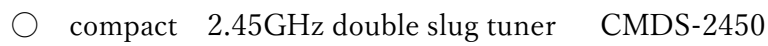
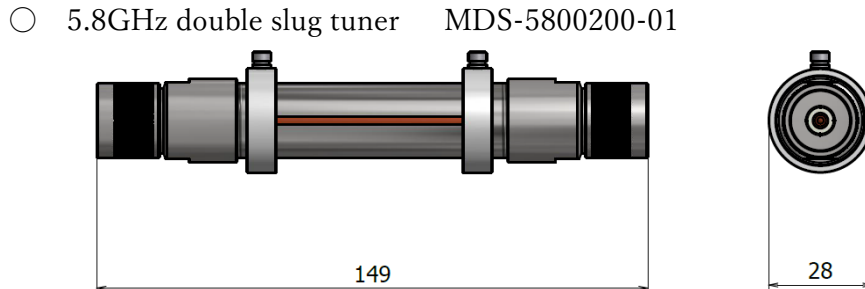
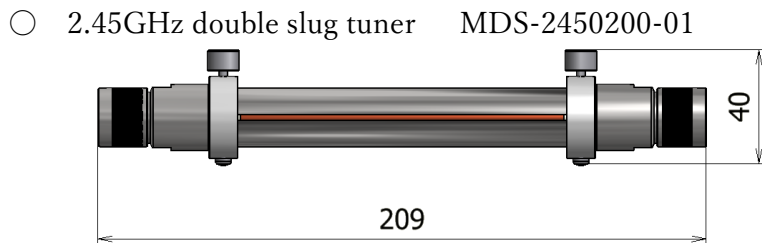
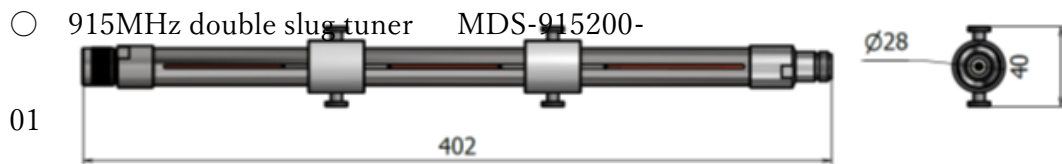
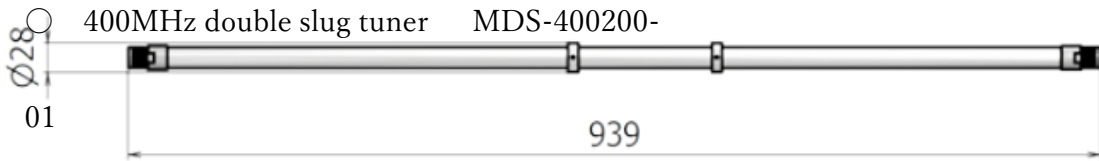
Item	specifications
Microwave power maximum	200W
Microwave frequency range	5.7GHz-5.9GHz
Insertion loss	0.3dB
Maximum controllable SWR	13
Input connector	N type (plug or jack)
Output connector	N type (plug or jack)
Connector for reflected power monitor	Serial interface
Power supply	AC100-240V

3. Double Slug Tuner (Manual Matching Tuner)

The two slugs are moved for optimal alignment, and the slugs are screwed. There are 5 MDS-400 for 400MHz, MDS-915 for 915 MHz, MDS-2450 for 2.45GHz and MDS-5800 for 5.8GHz.



List of Double slug tuners



Completed compact DST for 2.45GHz



Main Specifications

Item	specifications	
	MDS-400200-01	MDS-915200-01
Maximum microwave power	200 W	2000W (average power:200 W)
Microwave frequency range	390 MHz-410 MHz	880 MHz-930 MHz
Maximum insertion loss	0.3 dB	0.2 dB
Maximum tunable SWR	15	15
Impedance	50 Ω	50 Ω
Input connector	N type plug	N type plug
Output connector	N type plug	N type plug

Item	specifications	
	MDS-2450200-01	MDS-5800200-01
Microwave power maximum	200 W	200 W
Microwave frequency range	2 GHz-3 GHz	5.7 GHz-5.9 GHz
Insertion loss	0.17 dB	0.2 dB
Maximum tunable SWR	20	15
Impedance	50 Ω	50 Ω
Input connector	N type plug	N type plug
Output connector	N type plug	N type plug

Item	specifications
	CMDS-2450
Microwave power maximum	50 W
Microwave frequency range	2 GHz-3 GHz
Insertion loss	0.6 dB
Maximum tunable SWR	15
Input connector	SMA type plug
Output connector	SMA type plug

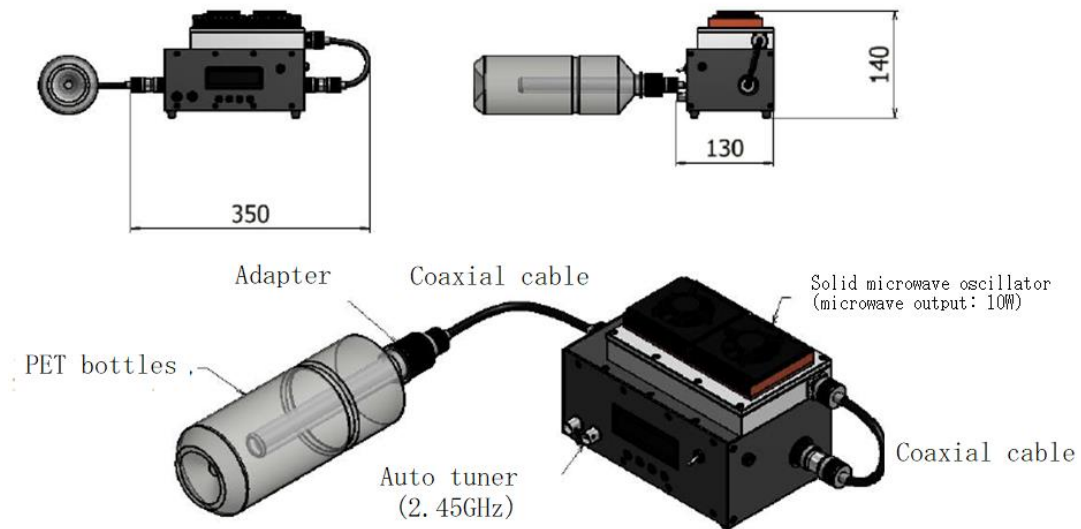


Strengths of technologies and know-how (novelty, superiority, utility)
<p>The advantages of the impedance matching tuners developed in this laboratory are as follows.</p> <ul style="list-style-type: none"> • Impedance matching can also be automated on load that is likely to change impedance, such as a microwave plasma. • The tuning speed and response time can be used as customers. • The equipment is compact as a whole. • Impedance matching is achieved in a short time (usually less than a few seconds). • Auto Tuner can be selected automatic mode and manual mode depending on the experimental purposes. • Auto Tuner can be used as a microwave reflected power monitor. • The consistency can be stabilized even if continuous use of Teflon slag with high mobility and durability is used.
Image of a cooperative company
<p>For example, you can work with the following companies:</p> <ol style="list-style-type: none"> 1) Companies and research institutes related to microwave plasma apparatuses and applications 2) Companies and research institutes related to microwave circuits and applications, not limited to plasma <p>In this lab, not only impedance matching tuners but also compact microwave power source and plasma generators are provided, so that various applications can be applied in combination with those apparatuses. For example, the following companies can cooperate.</p> <ol style="list-style-type: none"> 3) As compact microwave plasma apparatuses can be constructed as a whole, processing industry using microwave plasma and heat treatment. 4) Medical institutions, nursing homes, medical and nursing care equipment, food manufacturers, and food industry that require a large amount of sterilization treatment, as they can make use of microwave plasma apparatuses. 5) Other companies that are willing to commercialize and utilize this technology.
Utilization of technologies and know-how (images)
<p>Microwave plasma and others can be used for microwave equipment and applications that handle loads with impedance fluctuations. The followings</p>



are usage examples in which a microwave power source, an Auto Tuner, and a load are connected for the mercury lamp sterilization system (numbers in the figure are in mm).

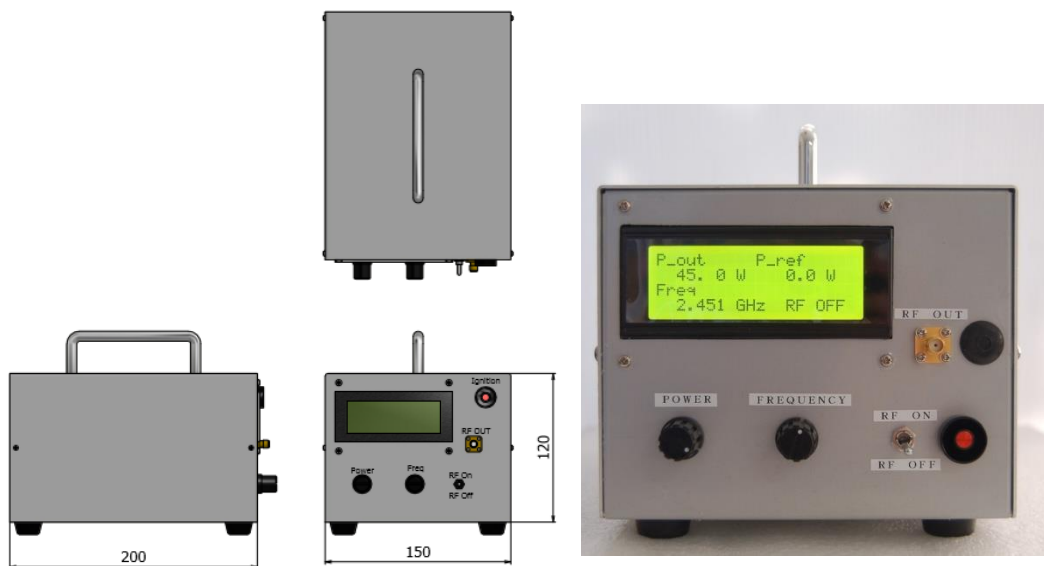
1) application to the mercury lamp sterilization system



2) Integrated Microwave Power Source (型式 Integrated MWPS)

For the users convenience, microwave power source, heat sink and cooling fan are integrated into the control box. So, users can use without assembling

those parts and can oscillate the microwave power by adjusting microwave power, frequency, which are shown on the LCD monitor.





Flow of technology and know-how
Please feel free to contact us if you are interested in utilizing this technology or product development.
Description of the technical terms
<p>【SWR(Standing Wave Ratio)】 SWR (Standing Wave Ratio) Standing wave ratio. If there is an impedance mismatch between the transmission line and the load, a reflected wave is generated from the load side, and a standing wave is generated by overlapping with the traveling wave. The ratio between the maximum amplitude and the minimum amplitude of this wave is called the standing wave ratio.</p> <p>【ISM(Industry Science Medical)】 (Industry Science Medical) Band It is a frequency band allocated for industrial science and medicine. There are 2.45 GHz, 5.8 GHz, etc.</p>