RF TRANSMITTER FOR ECR ION SOURCES

R. Boux, JP Ichac and M Soudée
THOMSON TUBES ELECTRONIQUES
BP 121 - 78148 VELIZY CEDEX - FRANCE

1. ABSTRACT

A growing number of accelerators, mainly cyclotrons, are using ECR ion sources to extend their possibilities. In ECR sources, the plasma which generates the ion beam is created by RF power. The microwave tube which delivers the RF power must be able to withstand large amounts of reflected power, due to mismatching induced by the plasma.

An especially designed transmitter, manufactured by TTE, can withstand continuous total reflection. It delivers 2 kW CW RF power, regulated at 0.1 %, and can also operate in pulsed mode.

This transmitter was built for the GANIL (Grand Accelerateur National d'Ions Lourds)

2. REQUIREMENTS FOR THE RF GENERATOR

The ECR (Electron Cyclotronic Resonance) ion source generates an ion beam by means of a plasma. About 2 kW of RF power is required to create the plasma.
When the source is tuned with stable operating conditions, the plasma operates as a matched load for the incident RF power.
The source cannot be tuned for RF matching under all operating conditions, for instance :

- when restarting the source after the vacuum chamber has been opened.

- With special tuning as for metallic ion production from solid samples.

In these cases, the RF power may be totally reflected by the plasma.

In a conventional transmitter, the microwave tube is protected from reflected RF by an interlock.

When feeding an ECR Source, the generator must operate normally regardless of any reflected power.

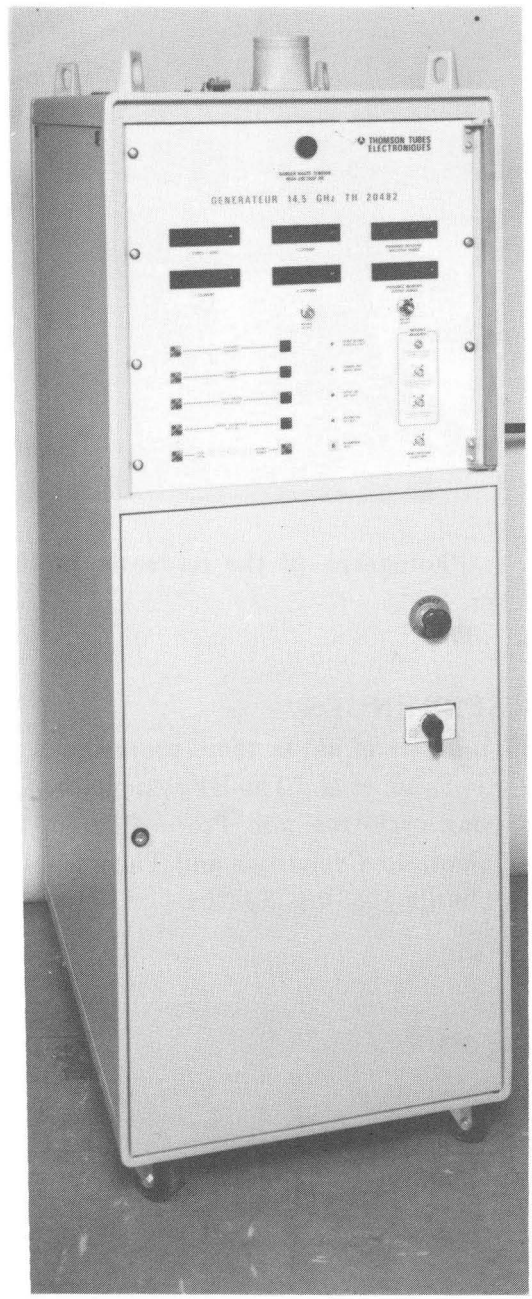


FIGURE 1 - TRANSMITTER CABINET

3. CARACTERISTICS OF THE 2 kW - 14.5 GHz GENERATOR

3a) CW mode

- Frequency : 14.5 GHz
- RF output power range : 10 W..2 kW
- RF output power adjustement : potentiometer on front panel.
- VSWR : any
- Power stability (line ± 5 %) : 0.1 %
- Power regulation response time : 1 ms
- Klystron cathode voltage : 9 kV.
- Klystron cathode current : 1.2 A

3b) Pulsed mode

- Minimum pulse width : 1 ms
- Maximum pulse repetition frequency : 1 kHz
- Maximum switching time (10 % to 90 % of amplitude) : 1 µs

3c) AC Line

- Line : 400 VAC - 50 Hz - 3 phases
- Power : 15 kVA

3d) Dimensions and weight (see fig. 1)

- Height : 1.510 m
- Width : 0.6 m
- Depth : 0.8 m
- Weight : 205 kg

4. PRINCIPLE

4.1. RF chain (See fig. 2)

Fig. 2 shows the principle of the RF chain.

- The power amplifier is a medium power klystron P/N TH 2464.
- A circulator at the RF output protects the klystron from the reflected RF. The matched load of the circulator can dissipate the full 2 kW of reflected power.
- The amplitude loop controls the low level amplitude by means of a PIN diode variable attenuator.
- The interlocks switch off the RF by means of a PIN diode RF modulator.

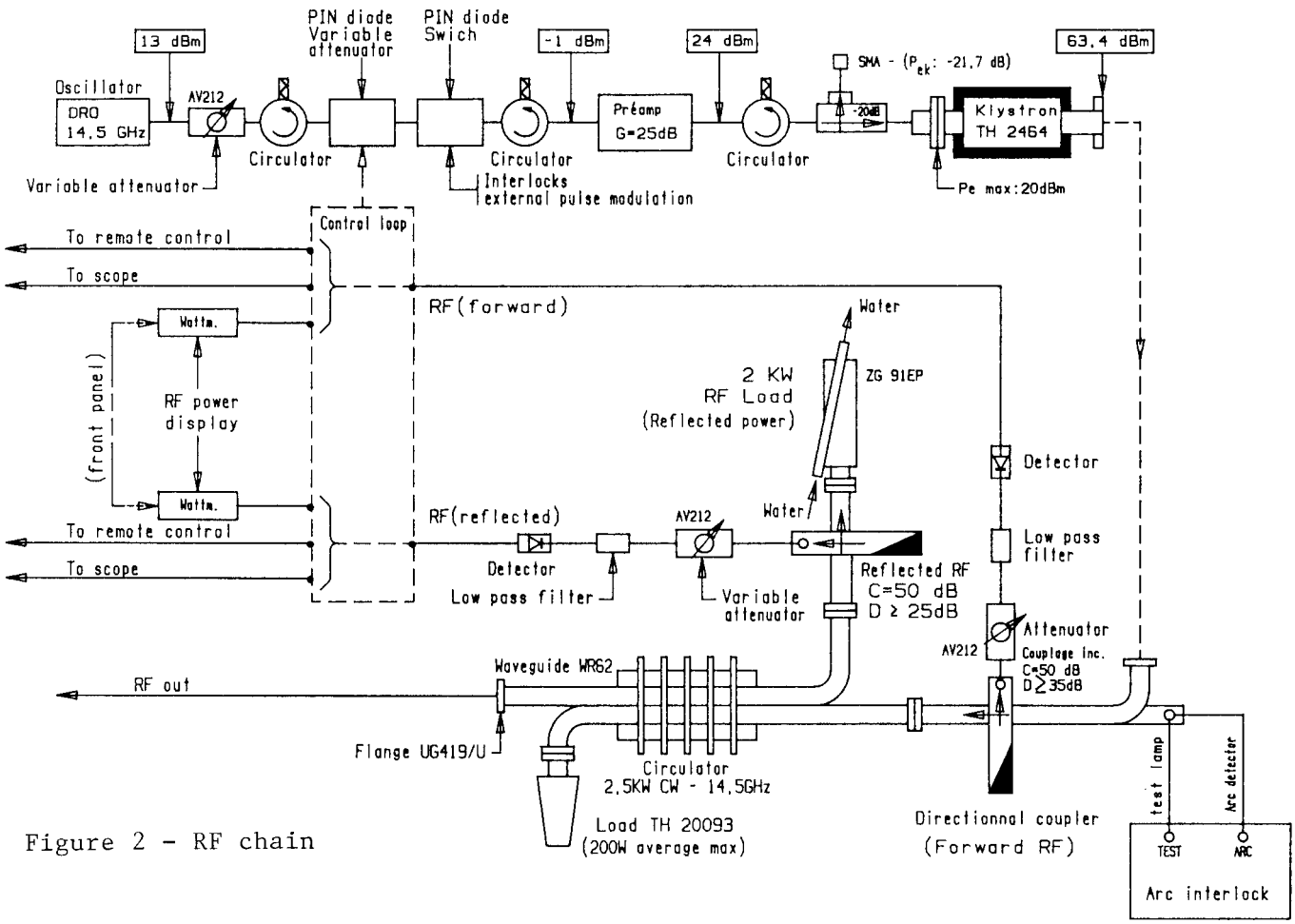


Figure 2 - RF chain

4.2. High voltage power supply

To achieve high stability of the RF power, the HVPS must have a low ripple.

The switching mode power supply results in both a low ripple and a low value of the energy stored in the filtering capacitor. Thus, a crowbar is not required.

A resonant switching mode is used, to reduce high frequency noise.

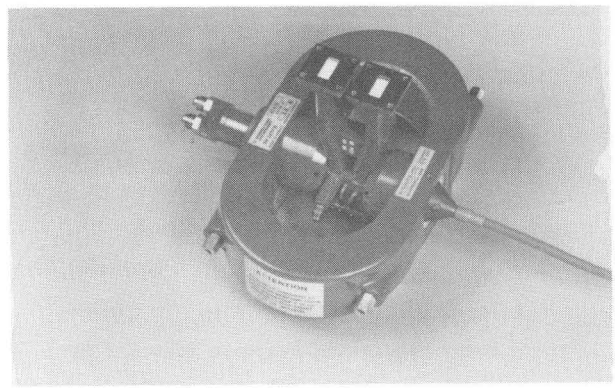
The switching mode power supply has small dimensions, compared to a conventionnal HV supply. The complete generator may therefore fit in a standard cabinet.

4.3. Power amplifier

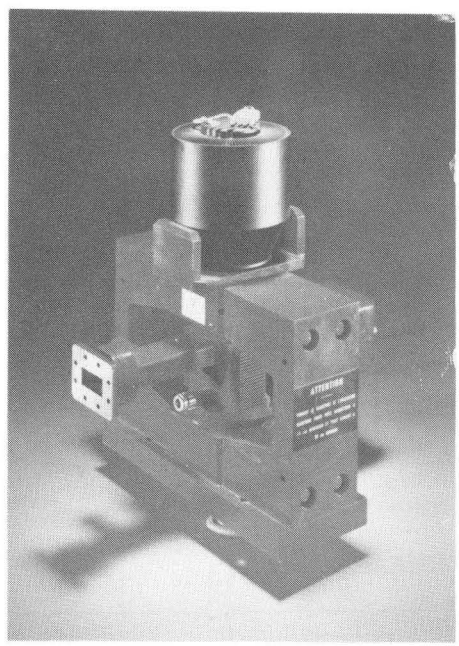
Medium power klystrons are the right choice to obtain a significant amount of CW power at frequencies required by present ECR ion sources. They are self-focused by permanent magnet, and can be fed by rugged and efficient power supplies ; they can work on a large dynamic range, are easy to install and reach a really high reliability.

The characteristics of medium power klystrons manufactured by TTE for ECR ion sources ar given hereafter ; with minor modifications, TH 20482 transmitter fits with all these klystrons and permits a larger flexibility for a long term and a cost effective investment of research laboratories.

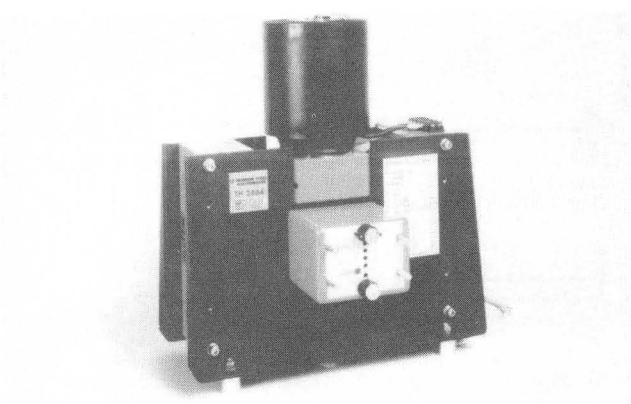
P/N	Frequency (GHz)	CW RF Power (kW)	Cathode Voltage (kV)	Beam current (A)	Cooling
TH2462	5.85-6.45	2	8.3	1.3	Forced Air
TH2461	7.9-8.4	1.65	7.2	0.63	Forced Air
TH2477A	9.5-10	2.5	10	0.9	Water
TH2477B	10-10.5	2.5	10	0.9	Water
TH2464	14-14.5	2	8.5	0.5	Forced Air
TH2463	18	1.5	12	0.5	Forced Air



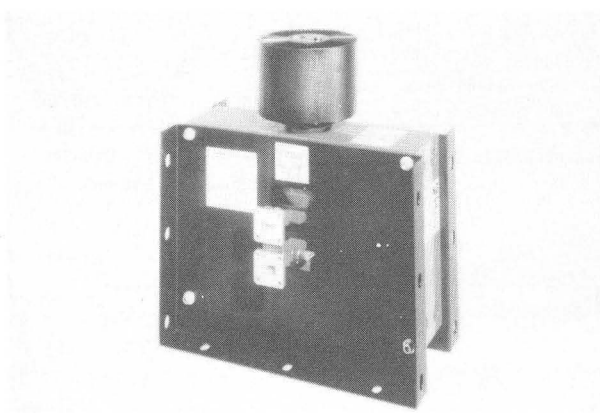
TH 2477



TH 2462



TH 2464



TH 2463