

# Research and Development in a High-Power 6.7 GHz Monotron

Joaquim J. Barroso, Pedro J. Castro, José O. Rossi, and José A. N. Gonçalves

Associated Plasma Laboratory, National Institute for Space Research - INPE  
12227-010 São José dos Campos, SP, Brazil

**Abstract:** This article overviews recent activities carried out in the construction and tests of a 10 kW, 6.7 GHz monotron. In addition to the monotron components—*injection electron gun, cavity resonator, and output waveguide*—, a hard-tube pulser with three tetrodes in parallel and able to produce negative voltages up to 30kV/20A from a positive DC charging power supply is also discussed.

**Keywords:** electron gun; microwave generation; monotron; high-voltage power supply.

## Introduction

Consisting of a cylindrical cavity driven by a round, hollow electron beam, the monotron is the simplest microwave generator, whose principle of operation relies on transit-time effects experienced by the electron beam propagating across a resonant cavity. Here we describe the main components and operation parameters of a device designed to generate 10 kW output power microwaves at 6.7 GHz. Currently under development at our laboratory, this monotron [1] currently operates with a beam of about 3.0 A at 10 kV as discussed throughout the paper in connection with the operating characteristics of the electron gun

## Main Components

The assembly (Fig.1) includes an injection electron gun, a resonant cavity coupled to the TM-mode output waveguide through a coupling hole. The cathode arrangement is devised to bend the equipotential surfaces so as to confine and focus the beam as the electrons move away from the emitting surface. The lower panel shows the electron beam bunched in the steady-state regime, in which DC beam power is converted into electromagnetic power at a typical 20 percent conversion efficiency. Without divergence, the beam is injected into the cavity through an annular slot, as can be viewed in Fig.2, whereas the fully assembled device is shown in Fig. 3. Since the cathode should operate at temperatures close to 1000 °C, the choice of materials for its construction is limited. As for the requirements of mechanical strength and low vapor pressure at high temperature, materials of low emissivity and poor thermal properties are needed to reduce heating power losses. The most suitable materials with such properties are the refractory metals and their alloys. Of these, molybdenum was selected for the cavity's entrance plate onto which, a pair of symmetric slots was drilled (Fig. 2). On the right and closing a ceramic pot, it is shown the circular cathode plate made from nickel on which the electron emission

coating is applied. Housing the heater filament inside, the ceramic pot is held by a circular disk of titanium. The supporting disk stays fastened to three circular stainless steel rods directly attached to the vacuum flange. The heater is made of a 0.5-mm-diameter pure tungsten wire tightly wound, with the resulting helix bent to take the shape of a toroidal coil (Fig. 4) housed on the back of the cathode disk to heat the emitting region radiatively.

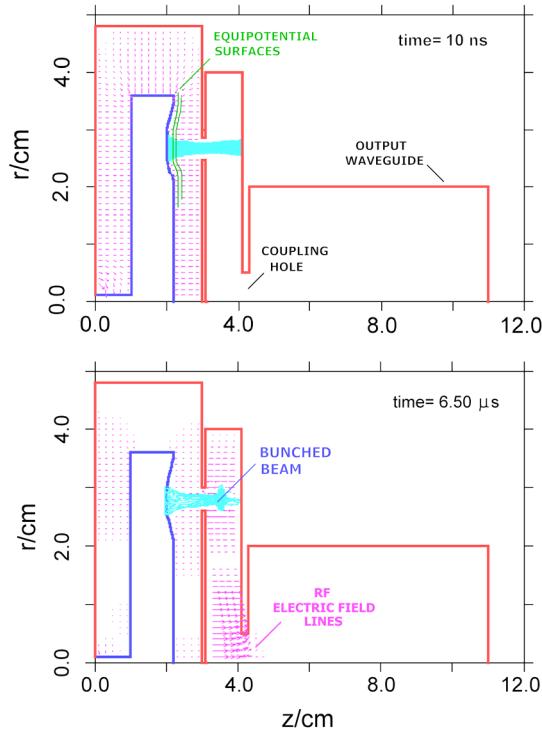
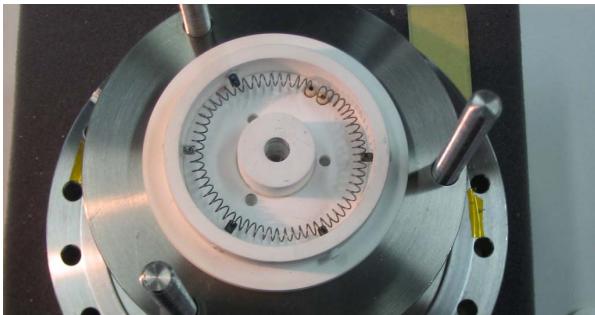


Figure 3. Front plate of the cavity and gun assembly



**Figure 2.** Full monotron assembled on a CF150 vacuum flange. The injection gun is shown in the middle part of the picture

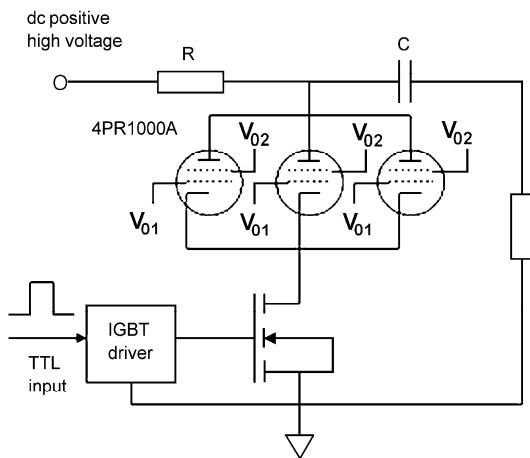


**Figure 4.** Heating tungsten filament housed in the ceramic pot

#### High-voltage power supply

The 6.7 GHz monotron had been operating at a pulse current of about 3.0 A, duration of 20  $\mu$ s with a repetition rate 50Hz, at a 10 kV beam voltage produced by a pulser configuration circuit [2] with a floating high voltage on-off switch. To be able to generate beams with still higher

current, we have developed a new configuration of power supply with three tetrodes in parallel (Fig. 5). In this scheme, the high voltage switch and its grid power supplies are near the ground, which eases the maintenance and the pulser construction. In fact, the on-off switching uses a power MOSFET in series with the cathodes of three tetrodes of 8A maximum plate current each connected in parallel. This type of circuit configuration is very convenient because the tubes withstand the major fraction of the blocking voltage as IGBTs operate at maximum voltages up to 1.5 kV and they do not require high power gate drivers.



**Figure 5.** IGBT-controlled high-voltage power supply with three tetrodes in parallel

#### Conclusion

With emphasis on compactness and ease of use, much interest has been devoted to microwave generators that do not require an external magnetic field so as to reduce cost, size and weight of the device. Owning to its inherent simplicity, the monotron enjoys such characteristics, as typified here by a 6.7 GHz developmental device.

#### References

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