§3. Simultaneous Operation of CPD and Non-CPD Gyrotrons by a Non-Regulated High Voltage Collector Power Supply

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The high voltage power supplies in the ECH system of LHD consist of three collector power supplies (65kV, 126A) and independent body and anode power supplies(Body: 90kV, 100mA and Anode: 50kV, 50mA) for each gyrotron. One collector power supply is roughly regulated and can operate three gyrotrons simultaneously.

During the first and second campaigns of LHD experiments the different types of gyrotrons were connected to one collector power supply. One was a triodes type and CPD (collector potential depression) 84GHz gyrotron and the other was a diode type and non-CPD 82.6GHz gyrotron.

Figure 1 shows a circuit diagram of such system. The CPD gyrotron requires an anode power supply for extraction of electron beams, a body power supply for beam-wave interaction, and a collector power supply for high power millimeter wave generation. For a CPD gyrotron high regulation of anode and body voltage (±0.3%) is needed, on the other hand rough regulation is enough for a collector power supply. A diode type gyrotron has a very simple structure. It has only a cathode and collector electrically. Electron beams are extracted, and accelerated by only collector potential. This means high regulation of a collector power supply is required. We had a chance to connect such different kind of gyrotrons to one collector power supply which has a rough voltage regulation (±5%). This trial was very challenging, because there was a possibility to occur oscillation stop for a diode tube by big voltage variation during operation.

However we could obtain a good operation region successfully shown in Fig. 2. When the collector voltage is turn on at first, a beam current begin to flow for the diode tube, and the collector voltage sags and recovers gradually because of slow feed-back control of thyristor valves. Next the body and anode voltage are switched on for the CPD gyrotron, then a beam current flows and oscillation starts. Figure 2 shows that gyrotron oscillations are retained successfully during such sequence.

Most dangerous problem is an oscillation mode jump which occurs in the diode tube. At the end of a usual sequence of high voltage application, the collector voltage is normally turn off 10ms (20ms in Fig. 2) after the anode and body voltage off. At that timing of long pulse operation, in which the collector voltage attains a steady value, the voltage jumps up due to a rapid decrease in the beam current, this leads to an oscillation mode change to another mode, and arcings sometimes happen in the tube by spurious RF generation. This phenomenon limited the operation regime to lower efficiency region.

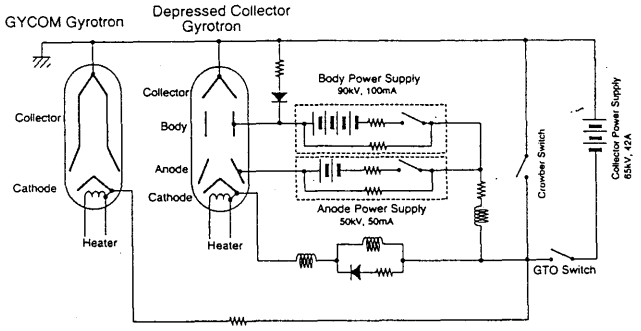

Fig. 1 Circuit diagram of power supplies and gyrotrons.

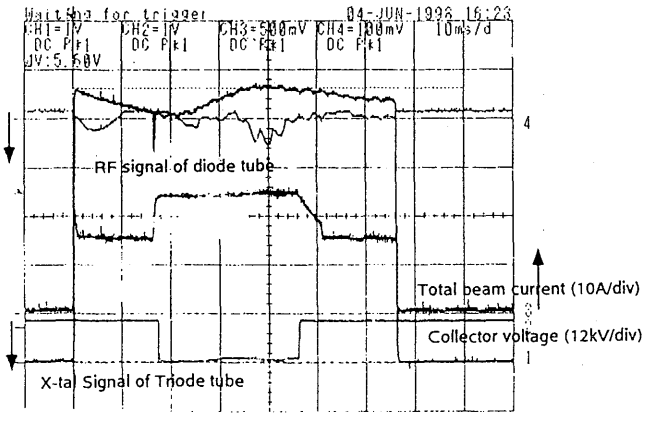

Fig. 2 Simultaneous operation of 84GHz CPD triode and 82.6GHz non-CPD diode gyrotrons. Oscilloscope traces correspond to collector voltage, output signal of diode gyrotron, beam current, and output signal of CPD gyrotron from top to bottom, respectively.