

60 kW CW (500 MHz) with a standard TV-Klystron

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Abstract

This paper will report about application measurements done with the 60 kW standard TV-klystron YK 1265. The performance of these tubes in cw-operation will be presented. An additionally report is given about a 48h test with 63 kW cw as well as a report about field experience and the reliability of this well known tube and also the standard accessory.

To achieve a higher efficiency it will be pointed to the possibility to use a TV-klystron with a four stage depressed collector, the YK 1285 PDC-tube (Philips Depressed Collector).

1. INTRODUCTION

The YK 1265 is a 60 kW TV-klystron with external cavities which has been proved for several years and over a hundred times in TV-transmitter and in the last time also in cw-application. Due to its compact design the required power for the electro-magnetic focusing is only about 1 kW. The collector is suitable for vapour, vapour-condensation or water cooling. The tube can be used with fixed frequency cavities (only tunable approx. 490-510 MHz) especially designed for the 500 MHz application, or with the standard cavities. These cavities have the advantage of being continuously tunable with digital frequency indicators for coarse tuning and thus offer a frequency range from 470 MHz to 810 MHz for cw operation. The output coupling is in a wide range adjustable for optimization in all application. With the new improved air cooling system for the cavities, drift tubes and socket the klystron need no separate cooling for the drift tube 5. The required air is approx. 3.2 m³/min with a pressure drop of 5.5 mbar or 550 Pa. A saturated output power of 65 kW is achievable, the saturated efficiency is 45 %. The gain is greater than 40 dB. The beam voltage is 25.5 kV and the beam current 5.7 A.

Easy spare parts storing and quick delivery from stock are two advantages of using a standard TV-klystron with its standard accessories for cw operation. A well proven technique and long life time expectation are pointing to the YK 1265. Because the YK 1265 is unchanged in its design, the monitoring of the body current will be helpful to ease the tuning procedure.

2. RF-PERFORMANCE

2.1 General RF-performance

The tuning of the tube is very similar to the tuning of a tube in sound operation to achieve a 3 dB bandwidth of 3 MHz. The output power is fully controllable via RF-drive or the mod-anode. Additionally there is the possibility of low voltage beam current modulation with the ABC-(Annular Beam Control) electrode. Figure 1 shows the output power and the ratio of body current to beam current versus the input power. It is easy to see how the output power and the body/beam current ratio behave in the near to saturation.

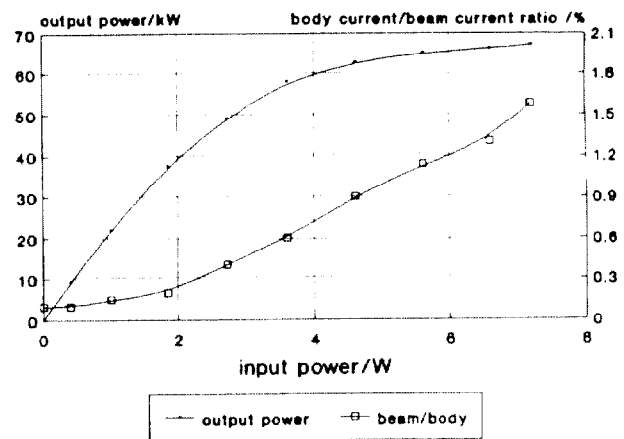


Figure 1. Output power and body/beam current ratio vs. input power

2.2 Phase Shift

In many cw applications the phase shift of the output signal in dependence of another changing value is of importance. Figure 2 shows the measured phase shift between input and output signal versus the beam current. The beam current was modulated by the mod.-anode. The phase shift has been measured relative to the phase of the output signal at nominal beam parameter and 63 kW.

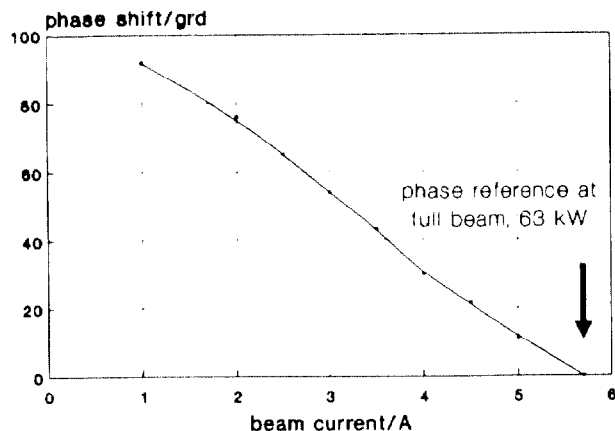


Figure 2. Phase shift vs. beam current

If the output power is regulated by the drive the phase shift of the output signal in dependence to the changed drive is of interest. Figure 3 shows this phase shift relative to the phase at saturated output power.

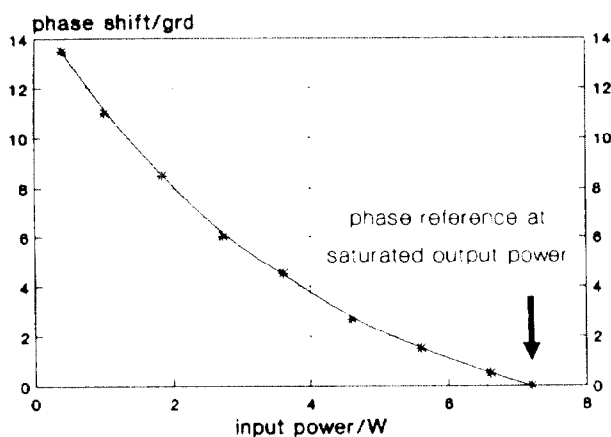


Figure 3. Phase shift vs. input power

2.2. Radiation

The operating tube generates X-rays, but the proper use of accessories will provide the necessary shielding. The cathode socket has to be shielded by sheet material. Under this operation conditions the X-ray emission will not exceed $2 \mu\text{Sv/h}$ (0.2 mRem/h) at a distance of 300 mm from the klystron or any part of the accessory.

The main source of rf-radiation would be a bad mounted third or fourth cavity, but with a proper mounting of the cavities the rf-radiation level can be easily held below $20 \mu\text{W/cm}^2$ (measured with Narda isotropic rf radiation monitor) in 300 mm distance from the klystron or any part of the accessory. The second source of rf-radiation, the 'last gap' between drift tube 5 and the collector, is suppressed by an additional external measure which is part of every radiation suppressor ring, a standard accessory. Thus the possibility of measuring the drift tube current remain.

3. PDC - POSSIBILITY OF ENERGY SAVING

The PDC-klystron YK 1285 is a standard klystron equipped with a five-stage depressed collector. Each collector segment along the beam axis operates at increasingly negative (depressed) potential to decelerate beam electrons entering the collector section. According to the electron velocities the beam electrons are sorted to impact the appropriate collector-voltage segments. The 'non utilized' beam electron power - after passing and leaving the rf-output interaction gap area - is significantly recovered and saved by the the power selecting process for the beam electrons by the staggered voltage stages of the collector segments [1]. Figure 4 shows the design structure of the PDC-klystron with the gun section, the four cavities and drift tubes, the five stage depressed collector and a schematic of the power supply.

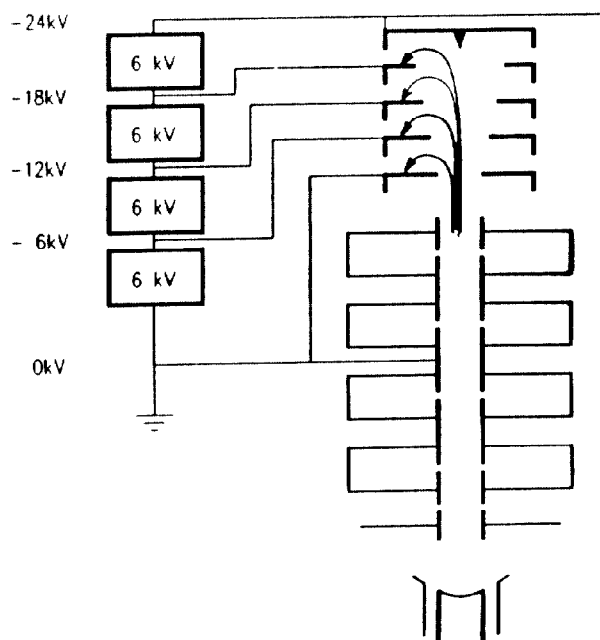


Figure 4. Design structure of PDC-klystron

This collector system will result in an improvement of the collector efficiency so that a power saving of approx. 30 kW is possible. Especially if the tube operates under full beam conditions but with reduced drive, the collector will recover a great amount of the 'non utilized' beam electron power.

A cost of ownership calculation has to decide, if this tube is an alternative for the customer. The price of this tube is about 50% higher than the standard tube.

4. PHILIPS TV-KLYSTRONS IN CW-OPERATION

To prove the reliability of the klystron YK 1265 in 60 kW cw-operation Philips performed a continuous operation

test at max. output power of 63 kW over a total of 54 hours. A standard tube with standard accessories was used. The YK 1265 including standard accessories has passed this reliability test without any interruption or irregularity. Drift tube temperatures did not exceed 55°C (as difference to the cooling air temperature), the output coupler or the cavity flange of the fourth cavity did not exceed 72°C (absolut).

Philips has several TV-klystrons in cw-operation. So in the Super Proton Synchrotron at Cern, Geneva: 450 kW/800 MHz high power source equipped with 8 klystrons YK 1198. In the Synchrotron light source at COSY, Berlin: 30 kW/500 MHz equipped with YK 1263. In the Synchrotron storage ring at Bessy, Berlin: 40 kW/500 MHz with YK 1195 and 2kW/500 MHz equipped with YK 1220. At the Synchrotrone Trieste: 60 kW/500 MHz equipped with YK 1265. In near future Philips will equip the Pohang Light Source, Korea and the DELTA project, university of Dortmund with YK 1265 in 60 kW/500 MHz application.

5. CONCLUSION

The TV-klystron YK 1265 with the standard accessories is well suited for 60 kW cw-operation and meets all requirements with regard to efficiency, radiation and reliability. Compact design, easy mounting and replacement as well as quick delivery of spare parts are the advantages of using a standard TV-klystron for cw-operation.

The use of the PDC-klystron YK 1285 in this application is very interesting but might be a to expensive alternative.

6. REFERENCES

- [1] W. Schmidt "Innovation and Introduction of a new MSDC Klystron Generation for High Efficiency UHF TV Transmitters", internal Philips report, Hamburg, September 1990