

TRC R2 # 1

There must be a full test of the JLC-X PPM klystron at the specified repetition rate of 120 or 150 Hz.

Summary:

This TRC R2 requirement has been satisfied. All key parameters have been met concurrently with a maximum output power of 75MW at 1.6 μ s pulse length at a repetition rate of 120Hz.

Recent results:

Three klystrons were tested in fall 2003, NLC XP3-3, JLC-X PPM-2 and JLC-X PPM-4. The XP3-3 klystron achieved a maximum output power of 75MW at 1.6 μ s pulse length at a repetition rate of 120Hz. In this test, all key specification requirements of GLC/NLC (peak power, average power, repetition rate, and pulse length) were met simultaneously. The tube then ran continuously at 65MW, 1.6 μ s and 30Hz without tripping for over a week. When attempting to return to full power, problems were encountered. Since this tube had a clamp-on magnet stack which was now judged to be a poor design, it was decided to rebuild it with an integral pole piece. The rebuild will be XP3-5.

The JLC-X PPM-2 klystron achieved a maximum power of 75MW at 1.7 μ s pulse length at 50Hz and 68MW at 1.7 μ s at 120Hz. It attained nearly the full average power of GLC/NLC klystron specification. The testing was terminated when the gun started to arc after the cathode voltage was raised to 500kV (corresponding to 72MW power) at 1.7 μ s and 120Hz. The JLC-X PPM-4 klystron was tested at KEK and achieved a maximum power of 75MW at 1.7 μ s at 50Hz. The repetition rate was limited to 50Hz due to the performance of the modulator.

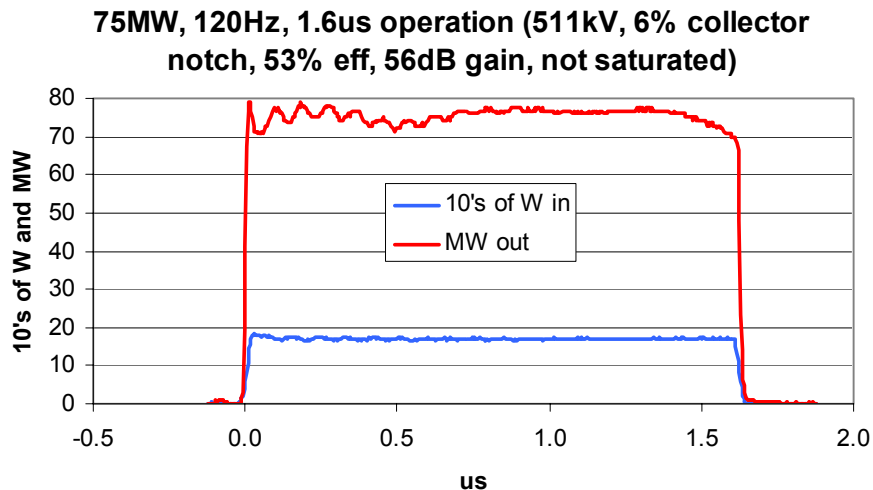


Figure 1. Waveform of the XP3-3 operating at full GLC/NLC specifications

Key issues:

A simplified scaling rule in microwave tubes parameterizes the relative difficulty of a klystron as proportional to the average power times the square of the frequency. For example, the PEP-II klystrons for the B-Factory rings operate at an average power of 1.2 MW (continuous service) at a frequency of 476 MHz. Scaling this to the GLC/NLC frequency produces an equivalent average power of 2.1 kW, where the GLC/NLC requirement is 14.4 kW, making the X-Band

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klystron seven times as difficult. For this reason, great attention has been given to the thermal design of the X-Band klystron, and the attainment of average power was the last requirement to be demonstrated. The efficiency of these klystrons (55%) means that some of the electrons in the beam have almost all of their kinetic energy removed and converted to microwave power. These electrons do not stay focused and deposit their energy in and around the drift tubes of the klystron where the materials are poor thermal conductors and the magnets react unfavorably to elevated temperatures. Having demonstrated this requirement is a major accomplishment for the X-Band RF source. Figure 2 shows average and peak output power for the PPM klystrons tested at KEK and SLAC. (Note that many of the tubes with low average power were test prototypes with little cooling, not designed for high rate operation.)

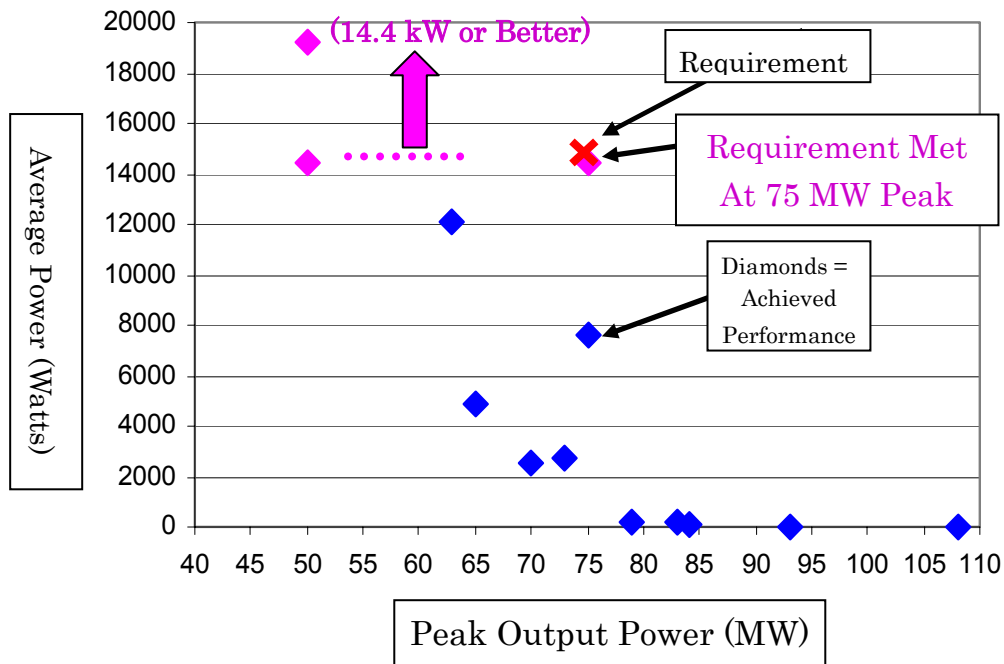


Figure 2. Average and peak output power achieved for X-band klystrons

Expected R&D:

A lifetime test at full specifications will begin in spring 2004 at NLCTA using a newly developed 2-pack IGBT induction modulator and two PPM klystrons. For this testing, both KEK and SLAC will provide one PPM klystron each. KEK will provide the JLC-X PPM-4 klystron and PPM-5 klystron as a backup. SLAC will provide the XP3-4 klystron and XP3-5 as a backup.

Testing of the JLC-X PPM-4 klystron is currently in progress at KEK after the windows were replaced by more robust Kazakov TE01 windows. The testing is expected to be finished by the end of January and then the klystron will be shipped to SLAC for a full test at 120Hz in March. The JLC-X PPM-5 klystron is already built and is waiting to be tested starting in February. It has a twice as much water-cooling and is equipped with SLAC TE01 windows. The gain cavities were also retuned for higher efficiency. It will be shipped to SLAC in April for a full test at 120Hz after all specifications except the repetition rate (limited to 50Hz) have been met in tests at KEK.

The NLC XP3-4 klystron was baked out in December 2003, and will be ready for testing at

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the end of January. The NLC XP3-5, the former XP3-3, is currently being rebuilt, and should begin testing in April. Both klystrons will have integral pole piece PPM focusing instead of a clamp-on magnet stack. A third klystron, XP4-1, with some improvements to the gun design, will be ready for test in June.

References:

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“Test Results /Plans for PPM Klystrons at SLAC”, A. Vlieks at ISG-XI meeting (12/03)

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