KLYSTRON OPERATION STATISTICS AT KEK ELECTRON/POSITRON INJECTOR LINAC

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Abstract
The KEK electron/positron injector linac is supplying 8 GeV electron beams to the KEKB high-energy ring and 3.5 GeV positron beams to the low-energy ring, as well as 2.5 GeV electron beams to the PF and PF-AR rings. This linac comprises a special accelerator module that includes a bunching section and 56 regular accelerator modules, each involves a 40 MW rf source with SLED and four 2-m accelerator sections operated at 2856 MHz. The operation time of the KEKB linac will amount to 7200 hours for fiscal year 2000 because of the heavy competition with the PEPB. More than 100 50-MW klystrons have been produced. Their average life time and MTBF value reached 13500 and 70500 hours, respectively, which shows an affirmative insight into achieving a desirable average life time of 30000 hours.

KEK ELECTRON/POSITRON INJECTOR LINAC

The KEK electron/positron injector linac was originally designed to provide 2.5 GeV beams to both the Photon Factory (PF) storage ring [1-2] and the TRISTAN accumulator ring (PF-AR). The linac upgrade for the KEK B-Factory [3] was carried out since 1994, while always keeping beam injection to the PF and PF-AR rings, and finished upgrading by May, 1998.

The major differences between the upgraded and old injectors are listed in Table 1.

Table 1
Differences between the upgraded and old injectors

	Old	**Upgraded**
Total energy	2.5 GeV	8 GeV
Linac length	400 m	600 m
Accelerator modules	41	59
Energy gain	8 MeV/m	20 MeV/m
Pulse structure	multi-bunch	single-bunch
Pulse repetition	50 pulse/s	50 pulse/s
Positron intensity	0.032 nC/pulse	0.64 nC/bunch

An 8 GeV beam can be provided by accelerating electrons along the entire linac length. In the 3.5 GeV positron-injection mode, a tungsten target is inserted into the beam line at the middle part of the linac; a high-current beam hits the target and part of emerged positrons is accelerated in the remaining part of the linac.

The electron source for the 2.5 GeV electrons to PF and PF-AR still remains at the original part of the old injector.

The upgraded injector comprises a special accelerator module that includes a bunching section and 56 regular accelerator modules, each involves a 40 MW rf source with SLED and four 2-m

accelerator sections operated at 2856 MHz.

50 MW KLYSTRON

A 50 MW klystron was developed for new rf system [4-5], expecting an enough margin at 40 MW operation. The specifications of the 50 MW klystron are shown in Table 2.

Table 2
Specifications of the 50 MW klystron

Beam voltage (kV)	304
Beam current (A)	352
Microperveance	2.1+-0.1
Beam pulse width (μs)	6
rf pulse width (μs)	6
rf top pulse width (μs)	4
Pulse repetition rate (pps)	100
rf frequency (MHz)	2856
Peak output power (MW)	50
Efficiency (%)	45
Gain (dB)	53
Focusing magnet	electromagnet
Pulse transformer step-up ratio	1 : 13.5

OPERATION STATISTICS

The operation time for the KEK electron/positron injector linac is shown in Table 3. It had increased to 7000 hours during FY 1999 due to the start of the KEKB experiment and will amount to 7200 hours for FY 2000 because of its heavy competition with the PEPB.

Table 3
Operation and failure rate

Period (FY)	**Operation time (hours)**	**Failure rate (%)**
1993	5299	0.88
1994	5070	0.78
1995	4563	0.74
1996	4123	0.62
1997	3828	2.88
1998	5906	7.12
1999	7297	7.36
2000	7160	

The cumulative klystron operation status up to March 2000 is shown in Table 4. More than 100 50-MW klystrons have been produced. Their average life time and MTBF value reached 13500 and 70500 hours, respectively, which shows an affirmative insight into achieving a desirable average life time of 30000 hours.

Table 4
Cumulative klystron operation status up to March 2000

Fiscal year of product	Total No. of tubes	Unused No. of tubes	Living		Failed		Cumulative operation (tube-hrs)	MTBF (hrs)
			No. of tubes	Av. op. time (hrs)	No. of tubes	mean age (hrs)		
1993	14	2	10	19184	2	20188	232212	116106
1994	13	0	11	17624	2	5857	205580	102790
1995	23	0	15	16212	8	7191	300705	37588
1996	15	0	12	14326	3	6707	192031	64010
1998	20	1	19	6668	0		126684	
1999	15	14	1	1884	0		1884	
total	100	17	68	13667	15	8649	1059096	70606

References

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