Proceedings of the Linear Accelerator Conference 1990, Albuquerque, New Mexico, USA

MICROWAVE SOURCE UPGRADE OF THE KEK 2.5-GEV LINAC RELEVANT TO B-FACTORY PROJECT

Tetsuo Shidara, Hiroyuki Honma, Katsumi Nakao, Shozo Anami and Akira Asami
1-1 Oho, Tsukuba-shi, Ibaraki-ken, 305 Japan

Abstract

The KEK 2.5-GeV linac is planning to upgrade its microwave source relevant to a B-factory project. The B-factory will use 8-GeV electrons and 3.5-GeV positrons where each injection energy from the linac is 2.5 and 3.5 GeV, respectively. The increase in the injector linac energy from the present 2.5 GeV necessitates the replacement of existing 30-MW klystrons with new 60-MW units. A doubling of the klystron output power requires a modification of the modulator system. The 60-MW klystron requires a 350-kV beam voltage pulse. A new pulse transformer with a step-up ratio of 1:15 will be necessary to deliver the increased voltage. The modulator, with the exception of its pulse-forming network, will be unchanged while producing the required power increase. The discussion will cover the upgraded modulator specifications and its test station using the 60-MW klystron.

Introduction

TRISTAN at KEK has entered a new phase (phase-II: luminosity run by employing superconducting quadrupole magnets[1]) in order to achieve an integrated luminosity of 300 pb^{-1} until 1995. What comes next? An asymmetric B-factory two-ring collider is considered to be phase-III of the TRISTAN project. The required beam energy and design luminosity are 8 × 3.5 GeV^2 and 1 × 10^{34} $/cm^2/sec$ from physics experiments.[2] Beam currents of 2.6 A for the 3.5-GeV positron ring and 1.1 A for 8-GeV electron ring are necessary in order to attain the design luminosity. The existing two injectors for the TRISTAN main ring, the KEK 2.5-GeV linac (see Fig. 1)[3] and the accumulation ring (AR), are also used for the injectors of the new B-factory rings.

The requirements from the B-factory project to the linac and its present status are summarized in Table I. Since the required injection energy of positron and electron beams for the B-factory are 3.5 and 2.5 GeV, respectively, the energy of the linac should be increased from the present 2.5 GeV to 3.5 GeV. Since the particle loss rate of B-factory rings is rather high, the intensity of the linac should also be increased in order to compensate for particle loss.

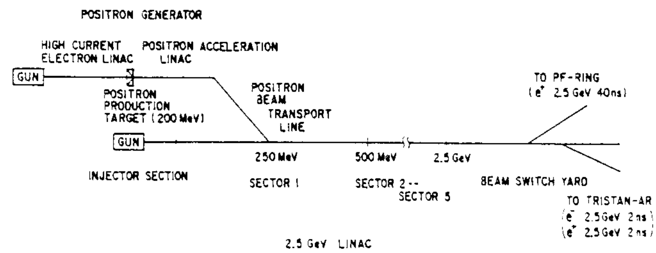

Fig. 1. Conceptual diagram of the present KEK 2.5-GeV linac.

TABLE I
Present Status of the Linac and Requirements from the B-factory

	present			B-factory	
	for AR		for PF	for AR	
	e^- 2ns	e^+ 2ns	e^+ 40ns	e^-	e^+
Energy (GeV)	2.5	2.5	2.5	2.5	3.5
Charge accumulation rate (× 10^{-8} C/min)	22.5	1.5	1 2	30 (75)	2 5 (75)
Pulse width (ns)	1	1	4 0	5 0	5 0
Peak current (mA)	1 5 0	1 0	2	2 (5)	1.6 (5)
Pulse repetition rate (pps)	2 5	2 5	2 5	5 0	5 0
Energy spread (%)	0.5	0.5	~1	~1	~1

This paper describes the upgrading of the KEK 2.5-GeV linac, especially its microwave system, in order to meet the demands from the B-factory project.

Linac Upgrade

A working group of the linac upgrade was organized in June of 1989 and has laid out several linac upgrade designs.[4] The following plan was tentatively adopted in order to satisfy the requirements from the B-factory project: I) In order to increase the positron intensity (1) positron beams with pulse width of 50 ns are accelerated; (2) the location of the positron production target is moved down to the 750-MeV point of the linac (see Fig. 2) since the positron-

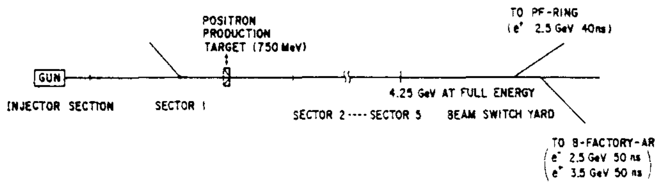

Fig. 2. Location of the positron production target in the upgraded linac.

production efficiency is proportional to the injection energy of the electron beams; and (3) the positron capture efficiency is improved by enlarging the acceptance of the focusing system. II) In order to increase the energy of the linac to 4.25 GeV (750-MeV electron beams + 3.5-GeV positron beams) all of the present 30-MW klystrons are being replaced with 65-MW high-power klystrons. The resultant accelerating gradient is 14.4 MV/m (see Fig. 3), which is sufficient for the linac with a total accelerating structure length of 300 m.

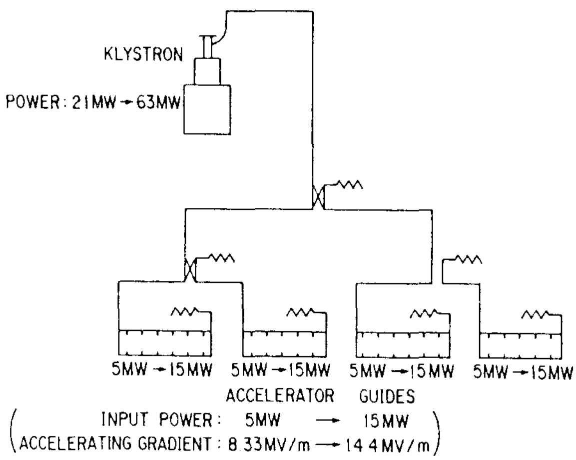

Fig. 3. Upgrade scheme of the power feed system to an acceleration unit.

Upgrade of the Microwave Source

Klystron

According to the SLC operation, 5045-type klystrons[5] are quite successfully supplying 65 MW of rf power. Therefore, we are planning to introduce this type of klystron as our new microwave source. Table II shows the specifications of the original and 5045-type klystrons.

Modulator

The doubling of the klystron output power requires a modification of the modulator system.

TABLE II

Comparison of the Original and Upgraded Klystron Specifications

	Original	Upgraded
Model designation	Mitsubishi PV-3030	SLAC 5045
RF peak output power (MW)	30	65
Beam voltage (kV)	270	350
RF pulse width (μs)	3.5	2.2
Repetition rates (pps)	50	50
RF gain	51	50
Micro-perveance	2	2
Efficiency (%)	40	45

Since the total modification of the modulator costs too much, the output voltage and average power of the modulator have remained unchanged. Consequently the 80 kV increase in klystron beam voltage could only be obtained by increasing the pulse transformer step-up ratio from the present 1:12 to 1:15. Accordingly, our new modulator is required to generate pulses with a 23.5-kV peak voltage, 6150-A peak current and 145-MW peak power. Table III shows the specifications of both the original and upgraded modulators.

TABLE III

Comparison of the Original[6] and Upgraded Modulator Specifications

	Original	Upgraded
Maximum peak power (MW)	84	145
Maximum average power (kW)	14.7	14.7
Transformer step-up ratio	1:12	1:15
Output pulse voltage (kV)	23.5	23.5
Output pulse current (A)	3600	6150
PFN impedance (Ω)	6.0	3.6
PFN total capacitance (μF)	0.3	0.3
Pulse width (μs)	3.5	2.2
Rise time (μs)	0.7	0.8
Fall time (μs)	1.2	1.5
Pulse repetition rate (pps)	50	50
Maximum pulse height deviation from flatness (%)	0.3 (peak to peak)	0.5
Maximum pulse amplitude drift (%/hour)	0.3	0.5
Thyratron anode voltage (kV)	47	47

Since the output impedance of the pulse-forming network (PFN) has been reduced from the original 6.0 Ω to 3.6 Ω, the PFN pulse width has also been reduced from 3.5 to 2.2 μs. Taking into account the pulse rise time of 0.8 μs and fall time of 1.5 μs for 65-MW rf pulses, a pulse flat-top of 0.7 μs is expected after the modification. Since the rf filling time of the accelerator guide is 0.5 μs, a 200-ns beam will be the longest case. This is the main reason why we have adopted the 50-ns beam for the B-factory project. A significant increase in the PFN discharge current is compensated using two PFN capacitors in parallel (see Fig. 4).

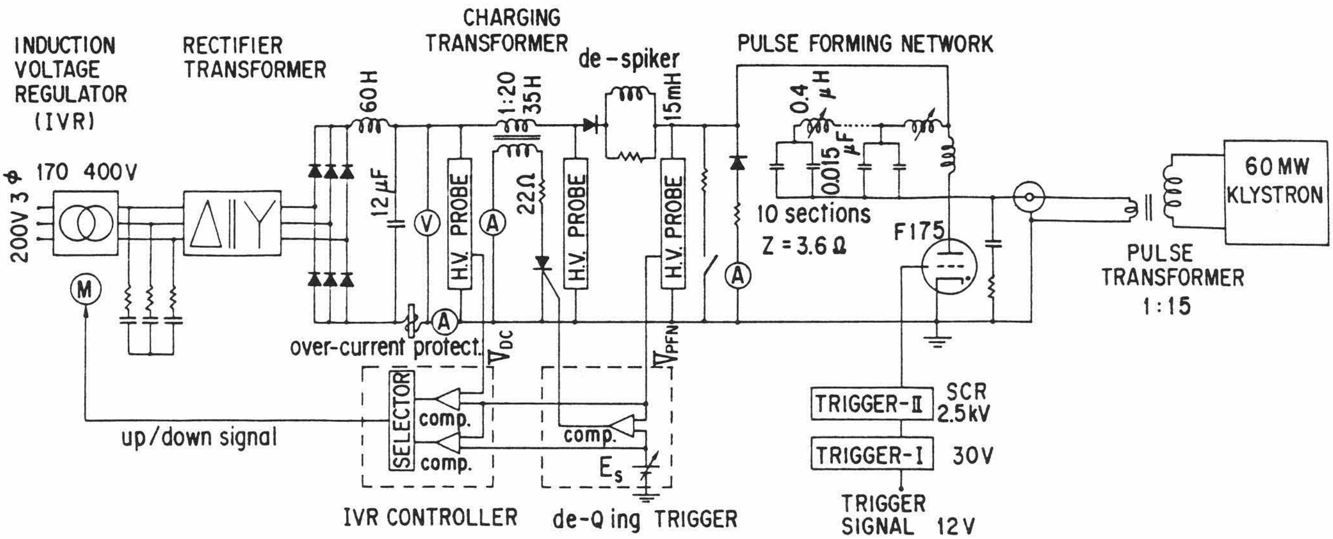

Fig. 4. Simplified diagram of the upgraded modulator.

Test Station

A new test station using a 5045-type klystron was established in order to confirm the above-mentioned modifications. This klystron is one of nine 5045-type klystrons which have been delivered from SLAC to the test accelerator facility[7] of the Japan Linear Collider (JLC) study group under the US-Japan collaboration program. The klystron has already been set at our test station (Fig. 5). A high-power test of this klystron using modified klystron modulator will start soon.

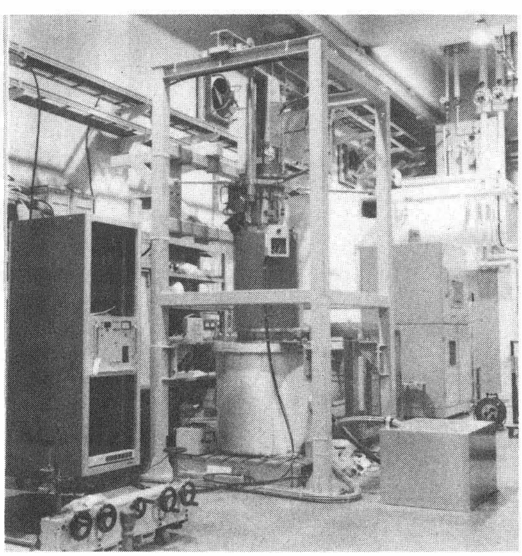

Fig. 5. 5045 klystron and tank assemblies set at a new test station.

Acknowledgements

The authors would like to express their thanks to Profs. K. Takata, and S. Takeda for their delivery of a 5045 klystron. One of the authors (T. Shidara) would like to acknowledge valuable discussions with Drs. M. Allen and A. Vlieks concerning the operation status of the 5045 klystrons at SLAC.

References

1. K. Tsuchiya et al., "Superconducting Magnet System for the TRISTAN Low Beta Insertion", KEK-preprint-90-56, June 1990.
2. ed. by H. Ozaki and Y. Yoshimura, "Feasibility Study for an Asymmetric B-factory at KEK", KEK-Report-90-7, June 1990.
3. J. Tanaka, "Construction of the Photon Factory 2.5 GeV Injector Linac", Nucle. Instr. Meth., **177**, 101 (1980).
4. A. Asami et al., "Linac Upgrade", Proc. of the Workshop on Asymmetric B Factory at KEK", KEK-Report-89-17, 252 (1989).
5. T. G. Lee et al., "A 50-megawatt Klystron for the Stanford Linear Collider", SLAC-PUB-3214.
6. T. Shidara et al., "Klystron Modulator for the KEK 2.5 GeV Linac", Nucle. Instr. Meth., **A279**, 423 (1989).
7. S. Takeda et al., "Electron Linac of Test Accelerator Facility for Linear Collider", Particle Accelerators, **30**, 153 (1990).