The 11th Symposium on Accelerator Science and Technology, Harima Science Garden City, 1997

Introduction of Solid State RF Sources at the KEK 40-MeV Proton Linac

Zenei IGARASHI, Kesao NANMO, Tateru TAKENAKA and Eiichi TAKASAKI
KEK: High Energy Accelerator Research Organization
1-1, Oho, Tsukuba, Ibaraki, 305 JAPAN

Abstract

At the KEK 40-MeV proton linac, solid state rf power amplifiers were introduced into rf sources for the two tanks of the DTL and for the prebuncher; furthermore, introduction to the debuncher's rf source is now in progress. These rf sources have been operated stably without any problem.
In this paper, the solid state rf sources and their operational results are described.

1 Introduction

Since construction of the KEK proton linac, four amplifier chains comprising many amplifiers using vacuum tubes (Fig.1) had been used as rf sources for the prebuncher, the two tanks of the DTL and the debuncher. However, these rf sources have caused problems due to the short-lived vacumm tubes or discharges of the high-voltage power supplies. In the latter half of 1980's, due to requests of easy maintenance, safty and reliability, an all soid state rf power amplifier generating several tens of kW in the VHF or UHF band for the rador system or TV transmitter were developed[1]. In that circumstance, we at first decided to use the solid state rf power amplifier as a predriver of the rf source for the 2nd tank.

2 The solid state rf power amplifier

The solid state rf power amplifier generally consists of some modules which contain several tens of rf power transistors, which generate several kW. Thus, for pulse operation we refined the module that was originally designed for cw operation of a TV transmitter by NEC corporation[2]. Figs.2 and 3 show the refined module and its blockdiagram. Fig .4 shows the output versus the input characteristics of the module. The rf power transistor used in the final stage of the module is the 2SC3286-M, adopting the so-called Gemini package, in which two transistor chips are mounted for push-pull operation, and generating about 200W. The maximum ratings and electrical characteristics of the transistor are given in Table.1.

Table.1 Characteristics of 2SC3286-M

Maximum ratings
$V_{CBO} = 55V$, $V_{CEO} = 32V$, $V_{EBO} = 3V$
$I_C = 24A$, $P_T = 280W$
Electrical characteristics
$P_O = 140W$ typ
@ f=230MHz, $V_{CC} = 28V$, $P_{IN} = 10W$
$P_O = 200W$ typ
@ f=230MHz, $V_{CC} = 37V$, $P_{IN} = 14W$
$\eta_C = 65\%$ typ

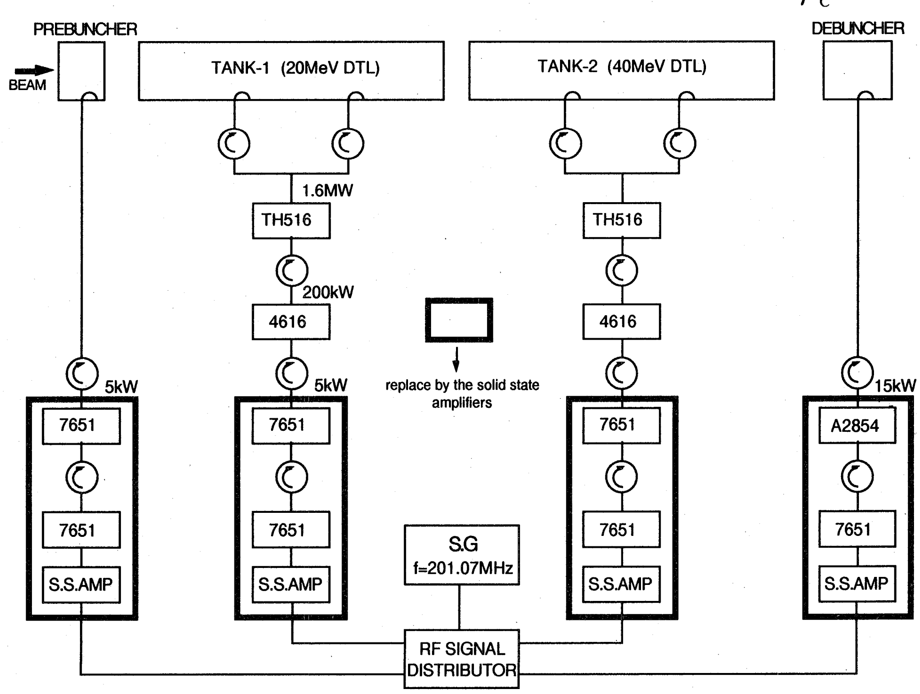


Fig.1 Block diagram of the rf sources for the KEK 40-MeV proton linac

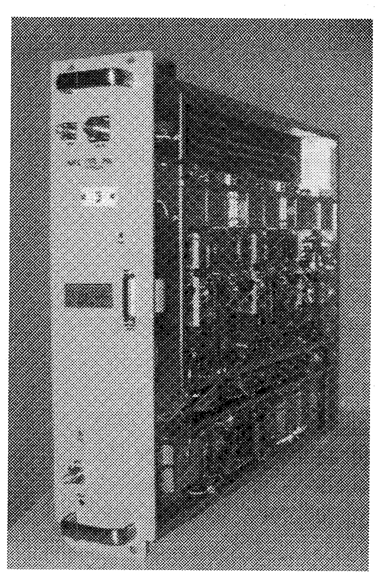


Fig.2 Module (type P2KCH)

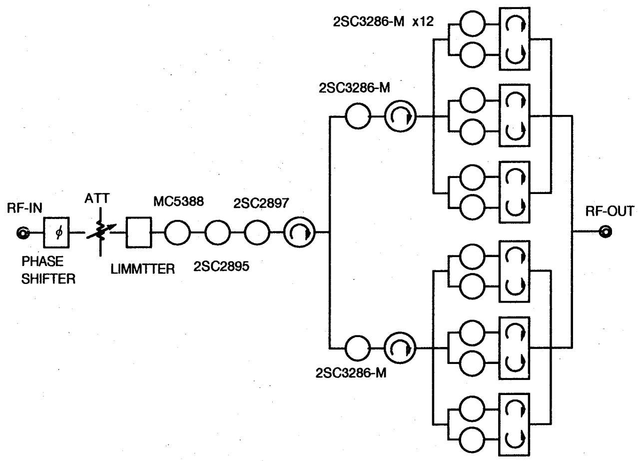


Fig.3 Block diagram of the module

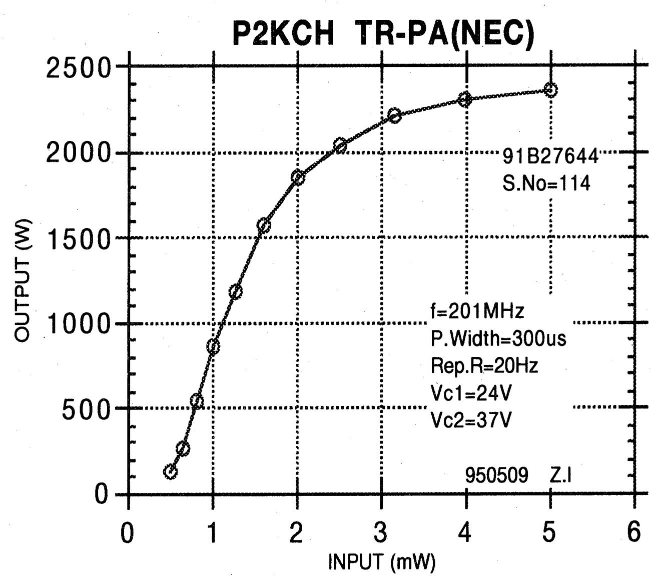


Fig.4 Output versus input characteristics of the module

2.1 Predrivers of the rf sources for the two tanks of the DTL

The predriver of the rf sources for the 2nd tank of the DTL, that contained the six modules and generated about 15kW, was introduced into the rf system instead of the 7651 amplifier, as can be seen in Fig.1 in 1988[2]. Fig.5 shows this predriver. To combine the outputs of the six modules, three coaxial 2-way combiners and a stripline 3-way combiner are used. This rf source has the function to increase its output power to compensate the beam loading receiving the trigger pulse. Since the solid state amplifier with an output power of about 15kW had operated very well, therefore, we introduced the same one into the rf source for the 1st tank in 1990.

Scince introducing the predrivers, we have experienced four problems which occured in the DC24V power supply, the blower for cooling, the trigger circuits, and the display pannel for displaying the output power, the AC voltage and the DC voltage. However we have never experienced any trouble in the module, itself.

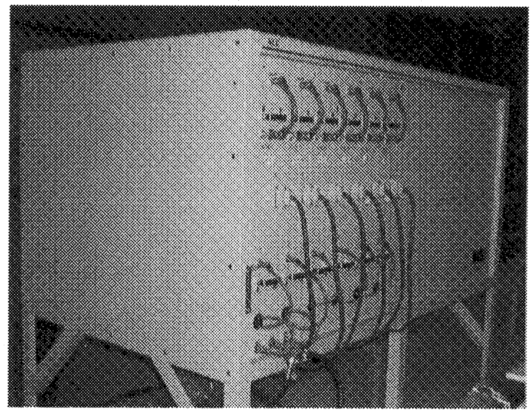
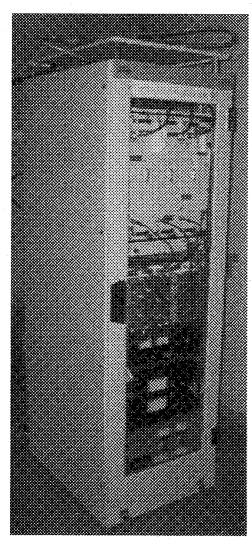


Fig.5 The predriver

2.2 Rf source for the prebuncher

The rf source shown in Fig.6 contains three modules and a stripline 3-way combiner[3].



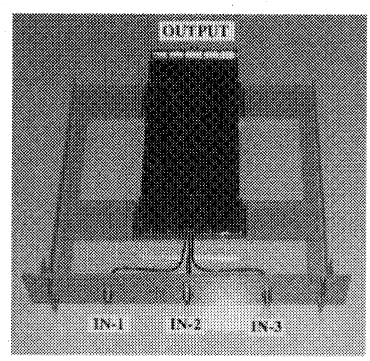


Fig.7 Stripline 3-way combiner

Fig.6 Rf source for the prebuncher

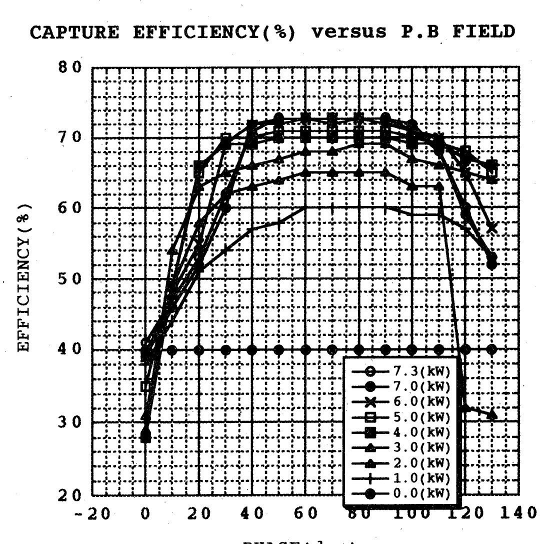


Fig.8 Beam capture efficiency versus the prebuncher field

The stripline forms the quarter-wave-length impedance transformer. Fig.7 shows this combiner.

Because this rf source stably generates 7kW larger than that of the old one, as shown in Fig.1, the beam-capture efficiency of the linac increase from about 60% to 74%[4]. Fig.8 shows the capture efficiency versus the prebuncher fields.

2.3The rf source for the debuncher

Containing the nine modules, this rf source, which joins three rf sources with just the same method as that for the prebuncher, generates about 20kW[5]. Three stripline 3-way combiners, which are the same as that for the prebuncher, and a coaxial (WX-39D) 3-way combiner (FIg.9) are used. Fig.10 and Fig.11 show the otutput, the phase versus the input characteristics and an output waveform of 20kW, respectively. The rf source is shown in Fig.12 after installation.

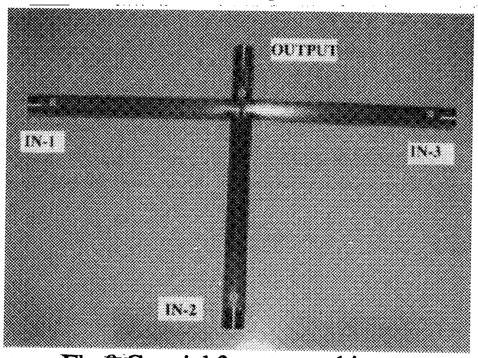


Fig.9 Coaxial 3-way combiner

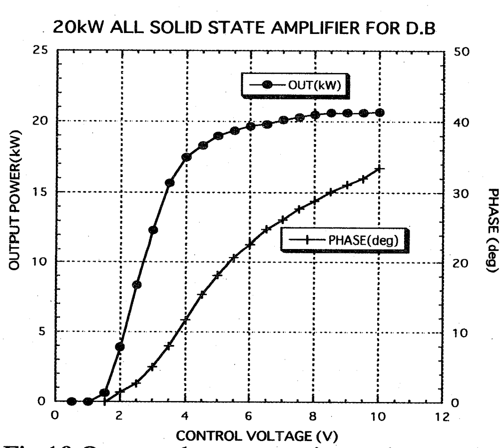


Fig.10 Output, phase versus input characteristics

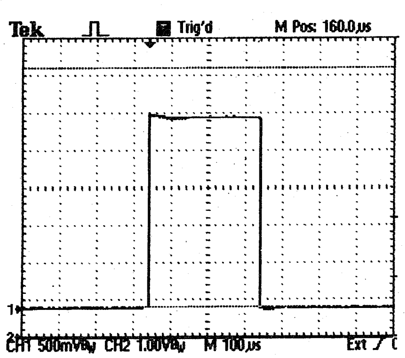


Fig.11 Output waveform of 20kW

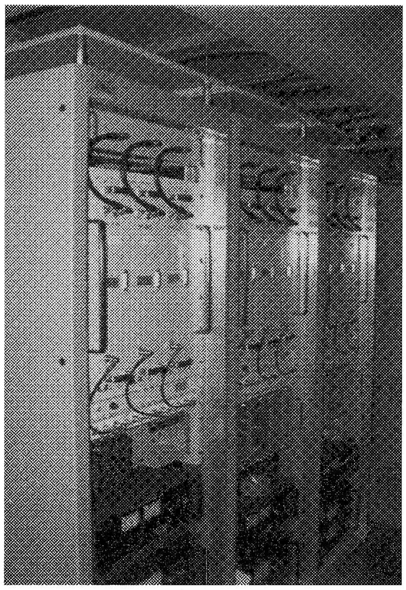


Fig.12 Rf source for the debuncher

3 Conclusion

Introducing the solid state rf source has decreased the problems during operation, improved the safety and reliability and facilitated maintenance. It is thus proved that an solid state rf source of several tens kW at VHF band works well for the proton linac.

Reference

[1]Z.Igarashi et al.," ALL SOLID STATE RF POWER AMPLIFIER FOR PROTON LINAC" Proc. 6th Symp. Acc. Sci. and Tech., 1987, p86.

[2]Z.Igarashi et al., "10KW ALL SOLID STATE RF POWER AMPLIFIER ", Proc. 13th Linac meeting , 1988, p34.

[3]Z.Igarashi et al., "RENEWAL OF THE RF SOURCE FOR THE PREBUNCHER AT KEK PROTON LINAC.", Proc. 21th Linac meeting , 1996, p195.

[4]E.Takasaki et al., "Effects of Controlling the 40MeV Proton Linac on Transversal Motions " Proceedings of this meeting.

[5]Z.Igarashi et al., "RENEWAL OF THE RF SOURCE FOR THE DEBUNCHER AT KEK PROTON LINAC ", Proc. 22th Linac meeting , 1997,.