ALL SOLID STATE RF POWER AMPLIFIER FOR PROTON LINAC

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ABSTRACT

Preliminary study of solid state rf power amplifier for KEK proton linac is described, putting emphasis on tests of high power rf transistors.

INTRODUCTION

Recently progressed semiconductor technologies make it possible to produce high power rf transistors which deliver more than a few hundred watts.Particularly,transmitters of broadcasting or radars introduce solid state systems in place of vacuum tube systems. TV transmitters of 50kW(VHF), 30kW(UHF) and radar systems of a few hundred kW are working well now.

The merits of solid state systems are
1)unnecessity of high voltage power supply---
free from dangerous apparatus.
2)high reliability---
easy maintenance.
3)redundancy.---
using transistors excessively, the system maintain the essential rf power level in case of failures of a few number of transistors.

The key points of solid state system are
1)selection of rf transistor
2)design of power divider/combiner
3)arrangement of isolators and interlock systems for protection of reflection and rf discharge.

Figure 1 and Table 1 show the present rf system of KEK proton linac. We intend to replace pre-driver stage, at first.

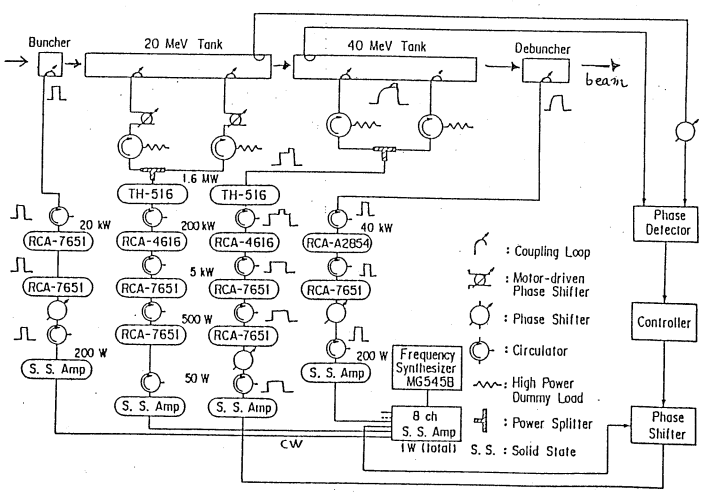

Fig.1 Block diagram of the present rf system for KEK proton linac.

Table 1

Parameters of the rf system for KEK proton linac.

output power	1.5 MW X 2
frequency	201.07 MHz
pulse width	300 μs
pulse width(driver stage)	400 μs
repetition rate	20 Hz

HIGH POWER RF TRANSISTORS

Figure 2 shows the largest rf transistors which can be obtained in Japan now. Righthand side of them is MOSFET (2SK317), the others are bipolar transistors (2SC3812,2SC3266) with twin structure for push-pull operation. Figures 3-5 and Table 2 show the test circuits and conditions. Experimental results are shown in Figs.6-8, and these transistors endured the total reflection at maximum output power.

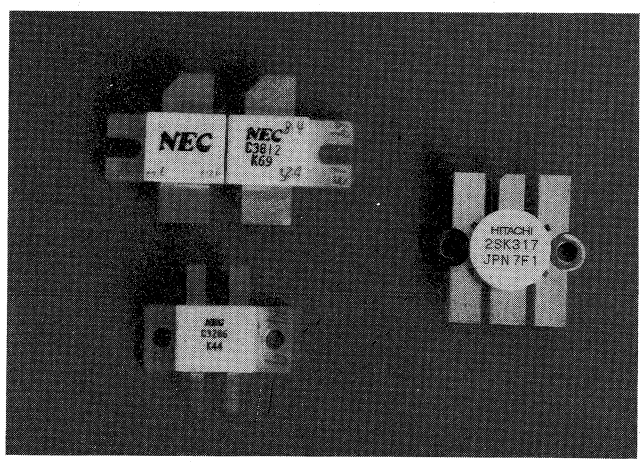

Fig.2 Rf power transistors (2SC3812,2SC3286,2SK317)

Table 2

Test conditions of rf transistor.

2SC3812, 2SC3286 (grounded emitter circuits)		
Vce (collector-emitter voltage)	35	V
Icq (quiescent collector current)	0.1 A X 2	
2SK317 (grounded source circuit)		
Vds (drain-source voltage)	120	V
Idq (quiescent drain current)	0.1	A

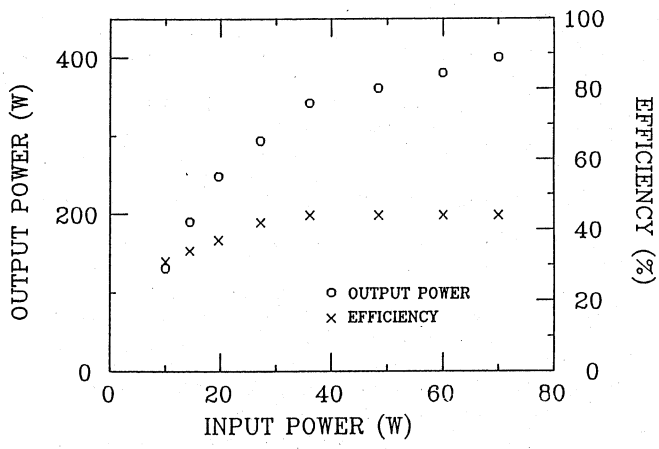

Fig.3 Output power versus input power.
2SC3812

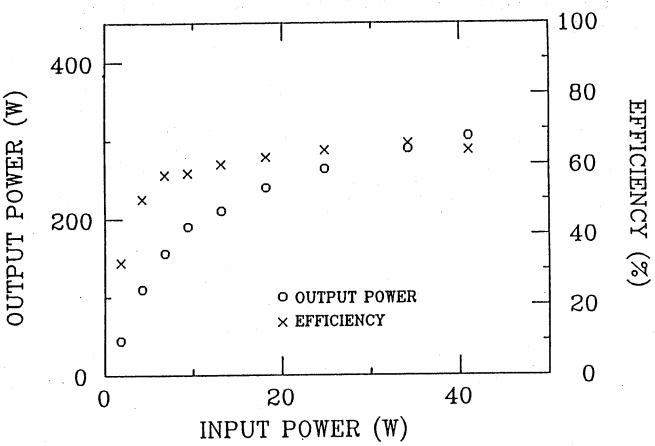

Fig.4 Output power versus input power.
2SC3286

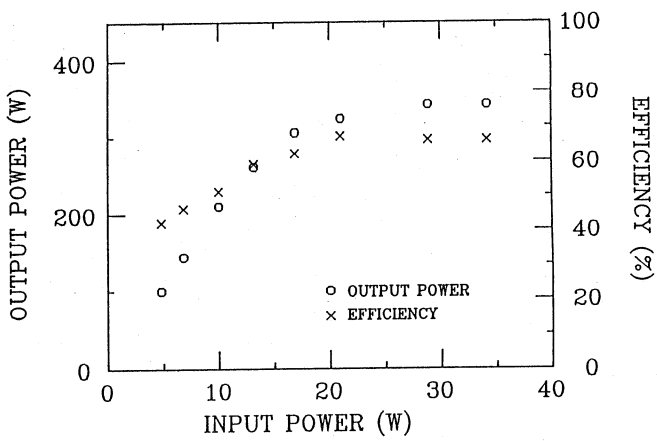

Fig.5 Output power versus input power.
2SK317

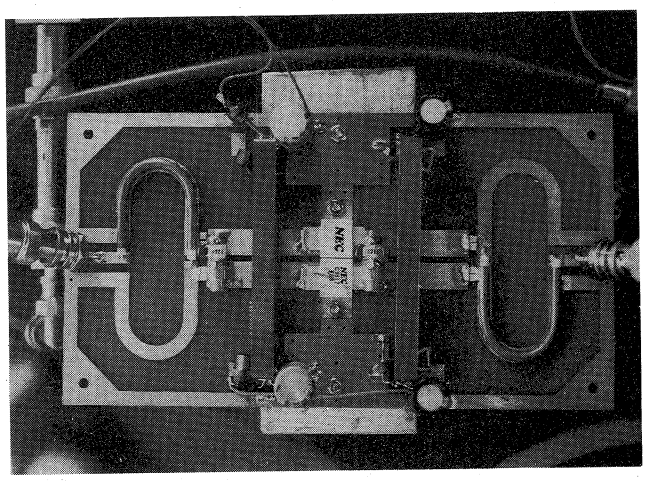

Fig.6 Test circuit of 2SC3812.

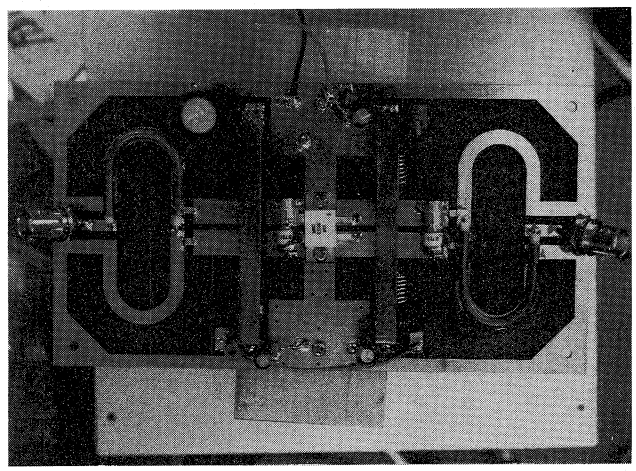

Fig.7 Test circuit of 2SC3286.

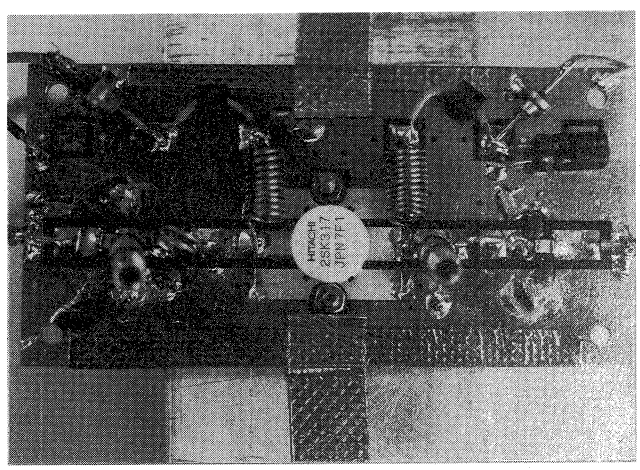

Fig.8 Test circuit of 2SK317.

The criteria for selection of transistor are

1)output power
2)power gain
3)input/output matching network
4)toughness for thermal shock and reflection power
5)power efficiency
6)cost per output power.

For the present, we adopt 2SC3286 (bipolar) and 2SK317 (FET).

POWER DIVIDER/COMBINER

The solid state rf system contains many transistor amplifiers operated in parallel, so input signal must be divided into the amplifiers equally and the output signals of the amplifiers must be combined effectively. The power divider and combiner are identical in their structure but their input and output sides are reversed. The output(input) ports of the divider(combiner) must be matched and isolated from one another. The matching and isolation are essential for the graceful degradation of the system when one or more component amplifiers fail, because in that case the failures should not affect the remaining amplifiers. Radial and fork type divider/combiners are suitable for the purpose and 8-port power divider/combiners of both types are being designed now.

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