DESIGN AND INITIAL DEVELOPMENT OF 1 KW PULSED S-BAND SOLID STATE POWER AMPLIFIER

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Abstract

We present design and initial developmental work for 1kW S-Band pulsed amplifier. This amplifier will be used for driving high power klystrons to be used in proposed accelerator test stand at RRCAT. The design is based on Class C pulsed power transistors to achieve higher efficiency. Proposed amplifier will provide ~1kW of pulsed power with 10us pulsed width and 300Hz repetition rate.

To achieve 1kW of output power, four 300W Class C transistors are combined using Wilkinson Power divider and combiners. Microstrip based Wilkinson power divider and combiners have been developed and tested, high power transistors have been ordered and are expected to arrive soon.

INTRODUCTION & DESIGN

Solid state power amplifiers are now an integral part of High Power Microwave systems. Technological advances in recent times enhanced the power output from a single device making it easier to obtain higher power with less number of devices. The accelerator test stand proposed at RRCAT will be using very high power (40MW-50MW) klystrons operating at 2856 MHz. To drive these klystrons we are developing a 1 KW pulsed amplifier taking into account the overall distribution losses and insertion of control components. Table 1 provides the design parameters of the amplifier.

Table -1 Amplifier design specifications

Parameter	**Value**
Operating Frequency	2856MHz
Bandwidth	± 5 MHz
Output Power(Pulsed)	1 kW
Pulse width	10us (max)
PRR	300 (max)
Gain	8.5dB

Since the amplifier will be operated at a very low duty cycle (0.3% maximum) Class C NPN transistors are selected as these have almost negligible bias current and hence D.C. power is consumed only during pulse ON time. This greatly reduces the heat load and hence simplifies the design.

On the flip side operation in Class C mode introduces harmonics and nonlinearity. But as the amplifier will be used as a fixed power driver to the klystrons which are tuned devices (O/P power will be controlled via a variable attenuator), nonlinearity and harmonics will not create much problems.

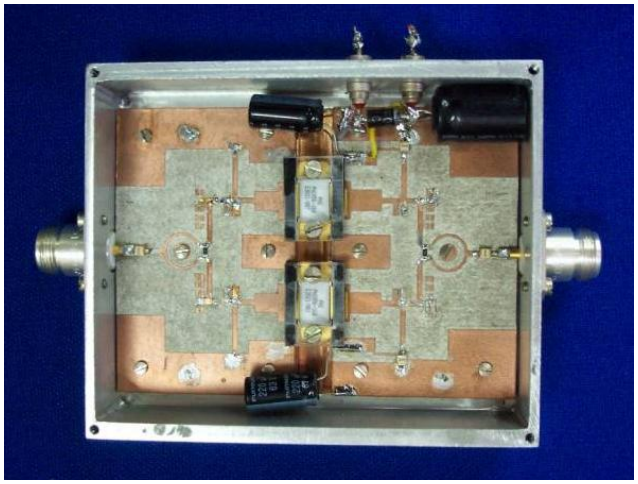

Figure1 300W Pulse amplifier module

We at RRCAT have previously developed 300W pulsed amplifiers at 2856MHz by combining two 160W NPN Class C transistors using Wilkinson divider/combiner (Figure-1). Now thanks to advances in transistor fabrication techniques, transistor providing 300W at S-Band are available, thus 1 kW can be achieved by combining only 4 transistors

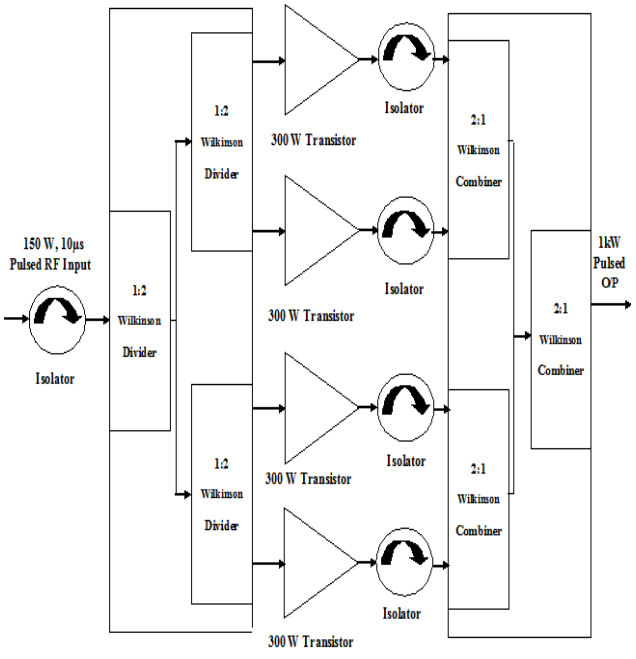

Figure 2 1kW S Band Amplifier Design

Fig. 2 provides the details of the amplifier design. The amplifier consists of four 300W S-Band pulsed power transistors independently matched to 50 Ohms at the Input and the Output stage. These are then combined together using Wilkinson combiner and divider to attain 1kW.

Among different combining approaches we have selected 2 stage Wilkinson divider/combiner, Wilkinson design is simple and easier to realize on a planar circuit. The amplifier is designed as a three stage modular amplifier consisting of Wilkinson divider, Amplifier Pallet consisting of four Transistors independently matched to 50 Ohms and Wilkinson Combiner. This allows us to independently test and characterize each module.

In order to protect the high power transistors getting damaged due to reflections all transistors are independently protected via isolators. The gain expected from each transistor is 10dB, assuming 0.5dB loss each for isolator, divider and combiner stages a total of 8.5dB gain is expected.

FABRICATION AND TESTING

The Wilkinson Divider and combiners have been designed and fabricated using in house prototyping machine. The 60 mil ARLON AD250 has been used as the substrate, its dielectric constant is 2.2. Microstrip calculations were done using Ansoft designer SV. Figure-2 shows the Wilkinson divider module.

Figure 3 Wilkinson Divider

The above module was tested using RF Power meter and R&S ZVB-8 VNA. Table- 2 below shows the results.

Table- 2: Measured performances of Wilkinson divider

Parameter	**Value**
Isolation	>24 dB
Amplitude Imbalance	0.2 dB
Phase Imbalance	5 º
Insertion loss	0.4 dB
VSWR	< 1.2

CONCLUSION

The design of the 1 kW SSPA has been done, Wilkinson divider and combiner have been fabricated and tested, and the results are as per expectations. We are awaiting the 300W S-Band transistors to arrive; the amplifier will be assembled and tested after receiving them. Based on our previous experience on similar type of amplifier we are confident of achieving the design parameters.

ACKNOWLEGDEMENT

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