SOLID STATE AMPLIFIER DEVELOPMENT FOR THE SWISS LIGHT SOURCE∗

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Abstract

The Paul Scherrer Institute (PSI) currently operates a klystron amplifier on the booster ring of the Swiss Light Source (SLS). In order to have an optional RF source for the booster cavity, we have been developing a compact 500 MHz 65 kW solid state RF amplifier. An important goal in this development is the optimization of efficiency at any given operating point. In order to achieve this, each RF module has been equipped with its own DC power supply (PS Controller), providing sufficient intelligence to adjust the drain and bias voltages in a fully independent and automatic way. With this technique it is possible to maximize the overall efficiency at any given RF output power. Considerable effort has been made in order to obtain extensive measurements from each individual module with the aim of investigating the behaviour of such a large number of combined arrays. We will discuss the amplifier design and present the results of measurements.

THE CONSTRUCTED 65 kW POWER AMPLIFIER SYSTEM

INTRODUCTION

Since the introduction of solid-state amplifiers on the synchrotron light source SOLEIL there has been considerable interest in use of such devices at other light source laboratories [1]. A modest R&D effort was started at the Paul Scherrer Institute (PSI) in order to develop this technology at 500 MHz resulting in a 4.5 kW prototype [2, 3]. More recently, supported by the Swiss Commission of Technology and Innovation, we have developed a 65 kW amplifier described in this paper. This technology has been transferred to AMPEGON AG, our industrial partner for this project, for industrialization and commercialisation.

DESIGN DESCRIPTION

A large variety of tests were performed to evaluate the 65 kW amplifier system described here. Long duration tests were done with the amplifier delivering output powers of, 60 kW, 64 kW, and 68 kW. The system performed in an extremely stable fashion under all conditions.

Figure 1 shows a block diagram of the system. In this configuration all the 108 output amplifier stages, those that contribute to the system output power, are placed in parallel and are all combined by a large high power combining structure [4].

MEASUREMENT RESULTS

Figure 2 shows the conceptual design of the proposed system. In the middle, one sees the high power combiner tree, a fundamental component of existing high power distributed amplifiers based on solid-state technology. The RF amplifier modules and the PS Controllers are mounted around the combiner tree on 2 meter tall aluminium bars which are water cooled.

Figure 3 shows the constructed high power solid-state amplifier system. The amplifier itself is placed to the right. It is composed of six 2 m long cooling bars. Each cooling bar supports 18 RF amplifier modules on one side and 18 PS Controllers on the other side.

The RF output of the amplifier system is connected to a 100 kW water cooled load through a 3 m long high power EIA 6¼ coaxial transmission line, seen at the top. The water cooled load is placed at the left of the amplifier, and behind the rack.

The 19° rack to the left houses part of the components required to connect the amplifier to the mains, other components for monitoring and communication purposes and the pre-amplifiers with their power supplies. The amplifier system is connected to the rack at the top through a cable support.

The complete amplifier system weighs approximately 900 kg.

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7: Accelerator Technology

T06 - Room Temperature RF
The 65 kW amplifier described in this work has performed very reliably and stably during a wide variety of tests performed, including full reflection at 60 kW, reduction of cooling, operation outside the center frequency (fre-
Table 1: Comparison Between Klystron Amplifier and SSPA

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<th>Booster</th>
<th>Storage Ring</th>
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<tr>
<td></td>
<td>Klystron</td>
<td>Klystron</td>
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<td></td>
<td>Amplifier (BO)</td>
<td>SSPA System</td>
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<tr>
<td></td>
<td>Cycled Ramp 3 Hz</td>
<td>1x65 kW</td>
</tr>
<tr>
<td>P_{out} Nominal</td>
<td>36 kW</td>
<td>36 kW</td>
</tr>
<tr>
<td>Efficiency</td>
<td>11.2%</td>
<td>46.5%</td>
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<tr>
<td>Price (Relative)</td>
<td>100%</td>
<td>22%</td>
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Figure 4: 65 kW system: P_{out} and Efficiency vs. P_{in}.

Figure 5: 65 kW system: Gain vs. Frequency.

Figure 6: Output frequency spectrum, P_{out}=60 kW, BW = 1 Hz and Span =1 kHz.

frequency scan) among others. At maximum output power of around 72 kW the efficiency of the whole system exceeded 53%, which, for the present technology, is a good result. The work performed until now in system performance optimization shows that this is promising.

Table 1 shows a cost and performance comparison between klystron and SSPA amplifier systems for both booster and storage ring. The performance parameters and the estimated prices are, in the case of the klystron amplifier systems, obtained from the SLS at the moment of the realization of this work, and, in the case of the SSPA, obtained from the present project. In both applications, booster and storage ring, the SSPA proposed in this work is very competitive and cost effective. Another promising advantage of the SSPA is that its operating point can be dynamically op-}

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REFERENCES