# DEVELOPMENT OF A 166-MHz 260-kW SOLID-STATE POWER AMPLIFIER FOR HIGH ENERGY PHOTON SOURCE

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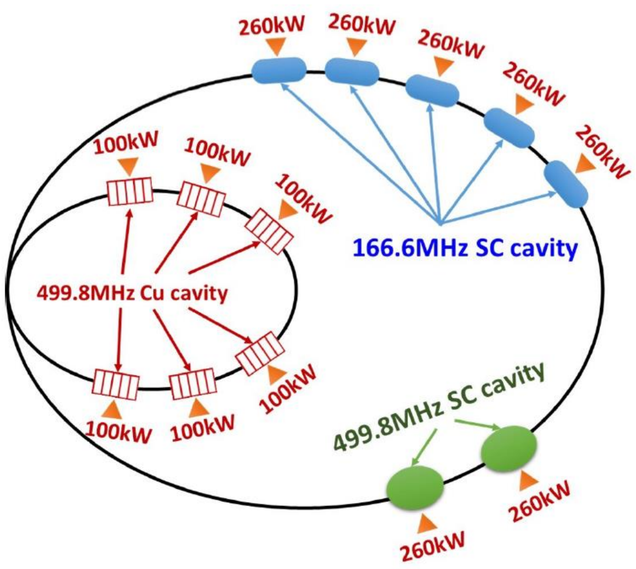
## Abstract

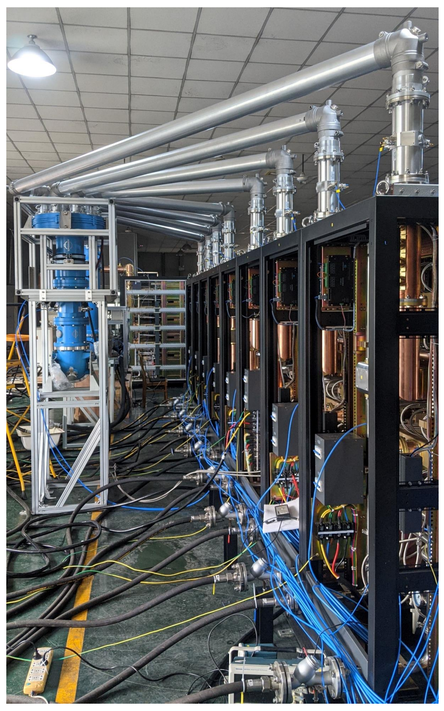
166-MHz 260-kW solid-state power amplifiers have been chosen to drive the 166.6-MHz superconducting cavities for the storage ring of High Energy Photon Source. Highly modular yet compact are desired. A total number of 112 amplifier modules of 3 kW each are combined in a multi-stage power combining topology. The final output is of 9-3/16″ 50 Ohm coaxial rigid line. Each amplifier module consists of 3 LDMOS transistors with individual circulator and load. Thermal simulations of the amplifier module have been conducted to optimize cooling capabilities for both travelling-wave and full-reflection operation scenarios. High efficiency, sufficient redundancy and excellent RF performances of the 260-kW system are demonstrated. A control system is also integrated and EPICS is used to manage the monitored data. The design and test results of the amplifier system are presented in this paper.

## 1. 166.6-MHz 260-kW SSA

RF system of HEPS



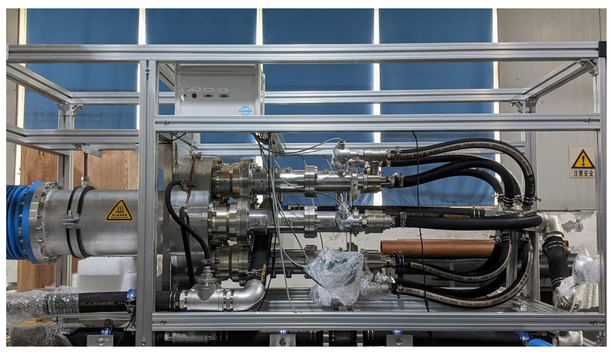

166.6-MHz 260-kW SSA



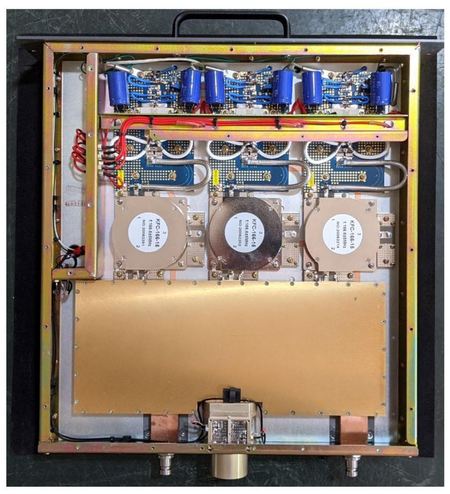
## 2. 8-way high-power combiner and load

8-way high-power combiner

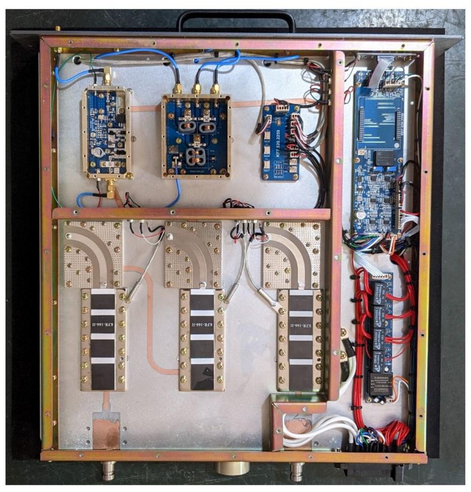
300-kW load



## 3. 3-kW amplifier module



(a)



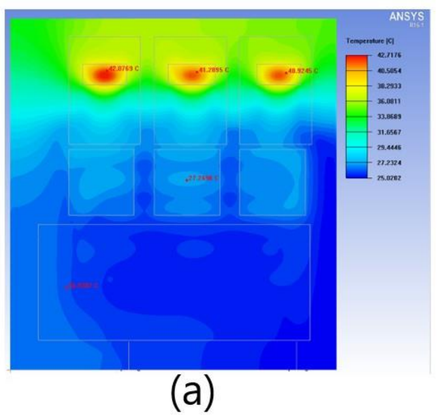
(b)

The 3-kW amplifier module: (a) front side view and (b) back side view.

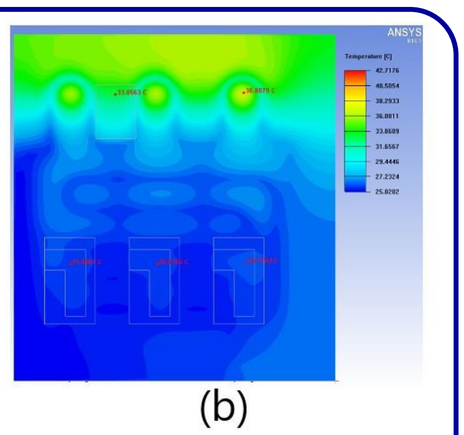
## 4. Thermal analysis

Thermal analysis of water-cooled plate

travelling-wave mode:
(a) front side view and
(b) back side view.

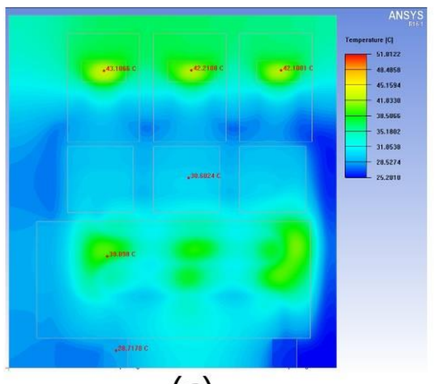


(a)

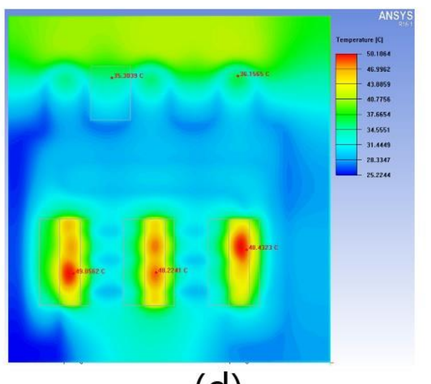


(b)

full-reflection mode:
(c) front side view and
(d) back side view.



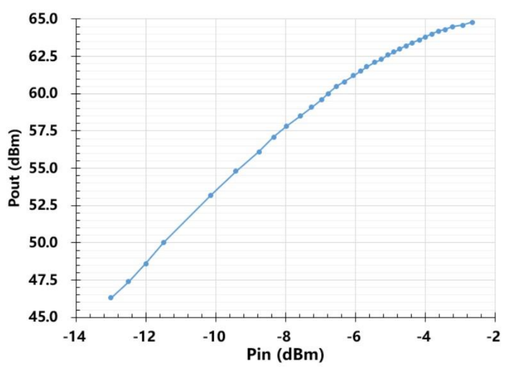
(c)



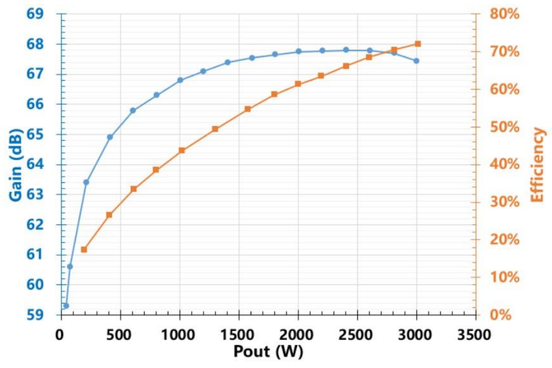
(d)

## 5. Test results of 3-kW amplifier module

| Parameters | Test result |
|---|---|
| Frequency | 166.6 MHz |
| P1dB | >3000 W |
| Amplitude stability (1 s) | ±0.1% |
| Phase stability (1 s) | ±0.1° |
| Amplitude stability (8 h) | ±1% |
| Phase stability (8 h) | ±1° |
| Harmonic | -36.5 dBc |
| Spurious within ±20 MHz | -79.5 dBc |
| Phase noise @10 Hz offset | -71.9 dBc/Hz |
| Efficiency (DC to RF) | 72.1% |




(a)




(b)

## 6. Test results of 260-kW SSA

| Parameters | Test result |
|---|---|
| Frequency | 166.6 MHz |
| nonimal output power | 260 kW |
| Second Harmonic | -35.5 dBc |
| Third Harmonic | -73.5 dBc |
| Gain at P1dB | 89.5 dB |