

# **Solid state rf power sources**





## Overview

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What is a solid-state RF generator?

The basic solid-state building block for power amplification and generation at RF and microwave frequencies is the RF power transistor. But before we look at details of its operation and use, let us take a high-level look at the potential benefits of solid-state RF generators for ISM applications.

How much RF power does a solid-state power amplifier need?

Because most industrial and scientific RF power applications need more than the 200–700 W that can be generated by a single solid-state power amplifier, one or more stages of power combining are usually needed.

What is a high-power solid-state RF transmitter?

A high-power solid-state RF transmitter contains hundreds of solid-state power amplifier (SSPA) modules. Each SSPA delivers a small portion of the RF-power; the combiner tree collects all RF-power of the individual SSPA modules to an output to deliver a high RF-power.

Can solid-state generators be used in ISM applications?

Nevertheless, as we shall see, the benefits they have ascribed to solid-state generators are (mostly) valid and can be valuably and immediately applied to a wide range of ISM applications. The basic solid-state building block for power amplification and generation at RF and microwave frequencies is the RF power transistor.

What RF sources are required for accelerators?

Overview High power RF sources required for all accelerators > 20 MeV • Amplifiers are needed for control of amplitude and phase • RF power output 10 kW to 2 MW cw – 100 kW to 150 MW pulsed Frequency range 50 MHz to 50 GHz Capital and operating cost is affected by Lifetime cost of the amplifier – Efficiency (electricity consumption) –.



Are RF-power sources heterogeneous?

As the two RF-power sources are heterogeneous, not identical in both power level and gain behavior, special attention becomes necessary to ensure that the RF-power seen at the inputs of the 3-dB hybrid coupler has the same power level with a quadrature phase offset for the maximum efficiency of the power combination.



## Solid state rf power sources

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### Microwave and RF Vacuum Electronic Power Sources



978-0-521-19862-2 -- Microwave and RF Vacuum Electronic Power Sources Richard G. Carter Frontmatter More Information In spite of significant progress with solid state power amplifiers during the last decades, large zones in parameter space remain

### New Developments on RF Power Sources

ceramics. Fine tuning of the focusing and of the RF working point as well as conditioning generally help. Other breakdowns linked to the HV and high RF fields, especially in the output coupler of the last cavity, occur on new klystrons but disappear with operating



- IP65/IP55 OUTDOOR CABINET
- WATERPROOF OUTDOOR CABINET
- 42U/27U
- OUTDOOR BATTERY CABINET

### Solid state class DE RF power source

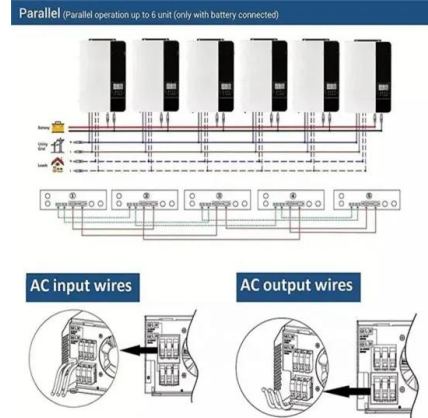
This paper presents the problems, solutions, results and feasibility of a Class DE inverter as an RF power source for frequencies up to 5 MHz and a power of 1 kW. At this ...

### High Power Solid-State Amplifiers. New Developments and ...

Figure 3: RF power stability. Power droop through pulse 0.13 dB. Figure 4: Rising and falling edges of 3.5 ms pulse, .10-90% rise time 0.24 us, fall time 0.235 us. To ensure the resistance of the system (which has no circulators) to the full



reflection, the tests



**A Compact 10 kW Solid-State RF Power Amplifier at 352 MHz**

A COMPACT 10 kW SOLID-STATE RF POWER AMPLIFIER AT 352 MHz D. Dancila, L. Hoang Duc, M. Jobs, M. Holmberg, A. Hjort, T08 RF Power Sources The amplifier is operated in Class B, with a quiescent drain current,  $I_{Dq} = 0.1$  A and a drain voltage

**RF Power Sources**

Tutorial: RF Power Sources J. Jacob, slide 4 0.1 1 10 100 1000 10000 100000 10 100 1000 10000 100000 f [MHz] RF Power [kW] RF power sources for accelerating cavities Tetrodes Diacrode Transistor amplifiers ? 300 W / unit x 600 IOTs CW Klystrons MBK



**Combining high-power heterogeneous RF sources for accelerator**

Facilities with a synchrotron light source at present utilize both vacuum-tube and solid-state RF sources to accelerate an electron beam, thanks to the rapid development of ...



### High Efficiency, Low Cost, RF Sources for Accelerators and ...

While the recent move towards solid state RF power sources exploits its many advantages, they are inherently poor performers with regard to efficiency, with maximum values typically less than 60% in terms of wall plug to RF power. A thorough analysis of the



### Combining high-power heterogeneous RF sources for accelerator

Theoretical and experimental efficiency of a RF-power combination at the target port of the 3-dB waveguide hybrid coupler, (a) on varying the power ratio of both RF-power sources with 90 phase offset and solid-state transmitter output power 70 kW invariant, and

### What is Solid-State RF Energy Technology?

Magnetrons deliver open-loop, crudely-averaged energy output, whereas with multi-antenna, solid-state RF energy sources, forward and reflected power levels can be easily assessed and adapted to with closed-loop, precision control over the frequency, output



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### Solid state RF power: The route to 1W per euro cent

In most particle accelerators RF power is a decisive design constraint due to high costs and relative inflexibility of current electron beam based RF sources, i.e. Klystrons, Magnetrons, Tetrodes etc. At VHF/UHF frequencies the transition to solid state devices promises to fundamentally change the situation. Recent progress brings 1 Watt per Euro cent installed ...



### High power experiments of the Prototype Solid State RF System ...

The current trend in the radiofrequency (RF) power systems of many large scientific facilities is the use of solid-state power amplifiers (SSPAs). When it is feasible, for mid ...



### High Power RF Solid State Amplifiers for Accelerators and ...

RF TRANSMITTERS FOR ACCELERATING CAVITIES  
2018/03/07 Page 3 ICFA FLS 2018 - Shanghai  
Institute of Applied Physics - March 5-9, 2018  
Jörn Jacob Auxiliaries Master Source LLRF RF  
distribution Pre-ampl. Power Amplifier  
Waveguide

### Solid State RF Power

of economics in solid state RF power sources. It seems that for VHF and UHF frequencies electron tubes finally become superseded by solid state solutions even at highest RF power levels.  
REFERENCES [1] O Heid, T Hughes. IPAC 2010, Kyoto, Japan.



### Solid-State RF Power Generators , SpringerLink

This chapter is intended to provide an overview of the benefits that solid-state RF generators can provide to industrial, scientific, and medical (ISM) 'RF energy' applications, ...





### Efficient Solid-State Power Amplifiers for RF Power Source

Tong, R. 2022. Efficient Solid-State Power Amplifiers for RF Power Source Applications. Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science and Technology 2169. 93 pp. Uppsala: Acta Universitatis Upsaliensis. ISBN 978-91



### Solid-State RF Power Generators , SpringerLink

Solid-state RF power has been used for decades in 1-500 MHz ISM applications. However, power generation in the important 915 MHz, Coherence is a valuable technique enabled by solid-state RF sources that is extensively used in RF test instruments to

### Solid State Amplifier (SSA) at FREIA

EnEfficient RF Sources, 3-4 June 2014, Cockcroft Institute, UK. 7 Solid State RF Power Station o Footprint: 2 m2 ( 4 x 19 inch cabinets) o Efficiency from wall plug to RF: 60% o Circulator not required o DC Power Supplies: 2 x 24 kW, 48 V o Power combiners:



- IP65/IP55 OUTDOOR CABINET
- OUTDOOR CABINET WITH AIR CONDITIONER
- OUTDOOR ENERGY STORAGE CABINET
- 19 INCH

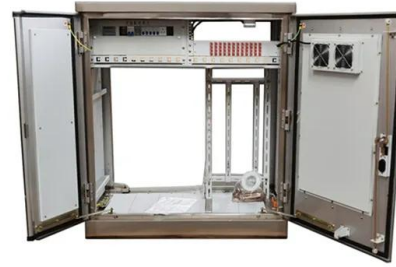
### Next Generation High Power Solid-State RF Sources

Solid-State RF State-of-the-art o Standard 300-600 W RF boards with one transistor - copies from evaluation boards o Tuned by hand matching circuits o Circulators (lose 5% to 7% efficiency) ...



### Solid State Power Amplifier at CERN

Available RF sources at a glance Solid State Power Amplifier at CERN, I.FAST Accelerator-Industry Co-Innovation Workshop, CERN, May 3, 2022 eric.montesinos@cern 8 10 100 1000 10000 100000 0 200 400 600 800 1000 1200 1400 1600 1800 2000 [kW]

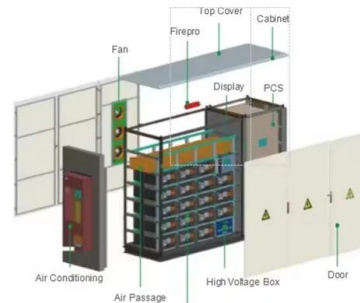


### Advantages of Solid State RF Power Sources

Subject - Radar Engineering Video Name - Advantages of Solid State RF Power Sources Chapter - Radar Transmitters Faculty - Prof. Kavita Tambe Upskill and get Pla Subject - Radar Engineering Video

### **High Power Radio Frequency Solid-State Amplifiers and ...**

Solid State RF Power Source for Optimal Power Consumption during the Charging of Superconducting Cavities," Manuscript. Reprints were made with permission from the publishers. Other publications The following papers were not included in this thesis.



### **High power experiments of the Prototype Solid State RF System ...**

The current trend in the radiofrequency (RF) power systems of many large scientific facilities is the use of solid-state power amplifiers (SSPAs). When it is feasible, for mid-range power levels at frequencies below 1 or 2 GHz, replacing vacuum technology for solid-state (SS) entails significant advantages.



## IPAC2021

The RF power source of the other 2 RF plants adopts klystron type transmitter and the 3rd RF plants is transferred to new technology of solid-state for better redundancy and easier maintenance. Base on the success of solid-state power amplifier development in 2020, a 3rd RF power source is thus decided to be made in house by solid-state technology.



### [RF power source , IARC at Fermilab](#)

and solid-state RF power sources, which typically have installed costs in the range \$5-15 per watt. Driving an SRF-cavity-based accelerator has more stringent requirements than simply providing heat for industrial processes; the RF source requires

## Here Comes the Solid-State RF Energy Evolution

The parallel evolution of solid-state RF energy technology and GaN-on-Si sets a clear path forward for OEMs competing for leadership in the aforementioned commercial markets. As these technologies



### [What is solid state RF Energy](#)

Solid-state RF-driven applications benefit from very agile control of the created electromagnetic fields (frequency, phase, power level, on/off can be changed on a microsecond timescale). The controller can react to any change or requirement instantly and can always guarantee optimal use of the irradiated RF energy for an optimal process result.





### RF Power Generation I

Tubes and Solid-state Amplifiers Professor R.G. Carter Engineering Department, Lancaster University, U.K. and The Cockcroft Institute of Accelerator Science and Technology June 2010 CAS RF for Accelerators, Ebeltoft 2 Overview o High power RF sources o



### Combining high-power heterogeneous RF sources for accelerator

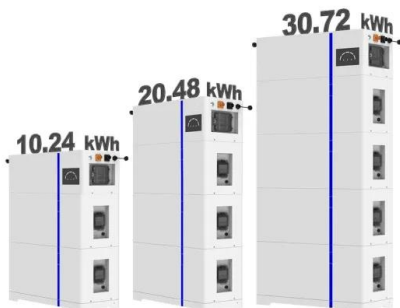
In this article, we report our successful combination of two heterogeneous high-power RF sources -- one a 100-kW klystron-based RF transmitter and the other an 80-kW solid-state RF transmitter, with a WR1800 3-dB waveguide hybrid coupler and an analogue low

### Modular High Power Solid State RF Amplifiers for Particle ...

of high power solid state RF amplifiers covering the power range of up to 150 kW for a frequency span of 72 T08 - RF Power Sources 1017 Figure 3: Block diagram of one amplifier section. Figure 4: Block diagram of CRE314. Each amplifier module contains



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### Efficient Solid-State Power Amplifiers for RF Power Source

2022 (English) Doctoral thesis, comprehensive summary (Other academic) Abstract [en] Radio Frequency (RF) power sources are extensively applied in various fields. Radioisotope production, i.e., the production of short-lived radioactive isotopes, for positron emission tomography (PET) is one of the most important applications in the medical and healthcare domains.



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