



भारतीय परमाणु अनुसंधान केंद्र
BHABHA ATOMIC RESEARCH CENTRE

SSA Control – DAE Requirements

for 325 MHz SSA

Manjiri Pande

BARC-SPC, IIFC

(on the behalf of SSA team)

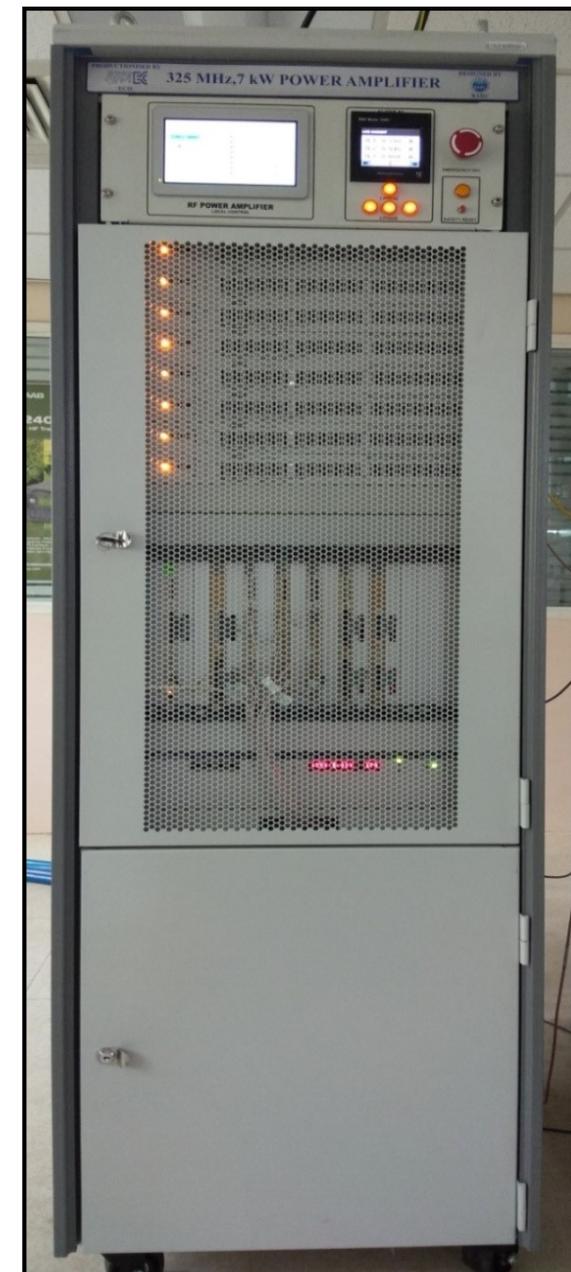
Outline

- 1) Introduction
- 2) Architecture of 325 MHz, 7 kW Solid State Amplifier (SSA)
- 3) SSAs
- 4) Requirements / Suggestions

Introduction

- ✓ BARC has designed and developed the lateral diffusion MOSFET (LD MOSFET) based high efficiency solid state radio frequency power amplifier (RFPA or SSA) (7 kW, 325 MHz) technology for its own accelerator program.
- ✓ Based on this design and mutually accepted Functional and Technical Requirements Specifications (FRS & TRS), SSAs are designed by BARC and productionised by ECIL.
- ✓ Six numbers of RFPAs already delivered to Fermilab and three more have reached Chicago or Fermilab.
- ✓ For PIP II Injector Test (PIP2IT) Facility of Fermilab, these BARC / DAE developed RF power amplifier (RFPA) / SSA systems are being coupled to superconducting cavities of single spoke resonator 1 (SSR1).
- ✓ Three SSAs are coupled to three cavities of SSR1 and 10.4 MeV* (H⁻) beam is accelerated (*Ref.: Plenary Talk by Lia in this workshop).

Description of SSA parameters	Specification
Frequency	: 325 MHz
RF Output Power	: 7kW Typical
1dB Bandwidth(MHz)	: 7MHz, minimum(± 3 MHz)
Power Gain	: 62-64 dB Typical
Group Delay	: <100ns
Phase of the amplifier gain over 10 dB dynamic range	: < 15 °
Temperature coefficient of gain($28 \pm 2^\circ\text{C}$)	: $\leq 0.04\text{dB}/^\circ\text{C}$
Temperature coefficient of phase ($28 \pm 2^\circ\text{C}$)	: $\leq 1 \text{ degree}/^\circ\text{C}$
AC to RF Efficiency(at 7KW)	: ~ 53 to 55%
All Harmonics	: <-25dBc
Spurious	: <-60 dBc
Input VSWR	: ≤ 1.5
Output VSWR	: ≤ 1.5
Connectors : RF in	: N(F)
RF Out	: 3 1/8" flange
AC power input to the rack of 7KW amplifier unit	: 3 \emptyset , 4 wire (Delta) 480/440, 60/50Hz 1 \emptyset -110V,60Hz



325 MHz, 7 kW Solid State Amplifier (SSA)

SSA - 7 kW at 325 MHz under DAE-Fermilab collaboration viz., Indian Institutes and Fermilab Collaboration (IIFC) delivered to Fermilab



1st SSA/RFP system at FNAL



Five SSA/RFP systems dispatched & reached to Fermilab in Oct 2020

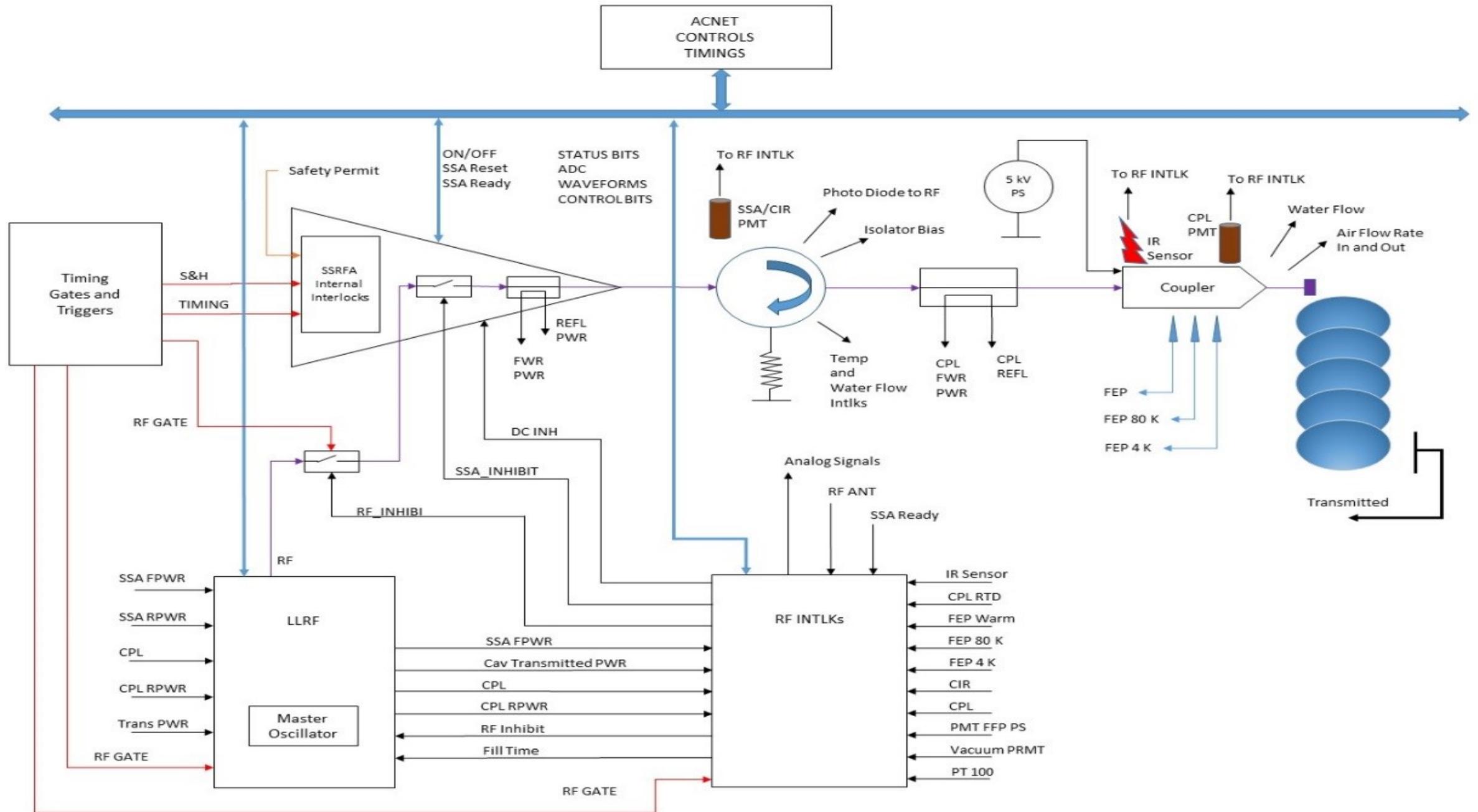


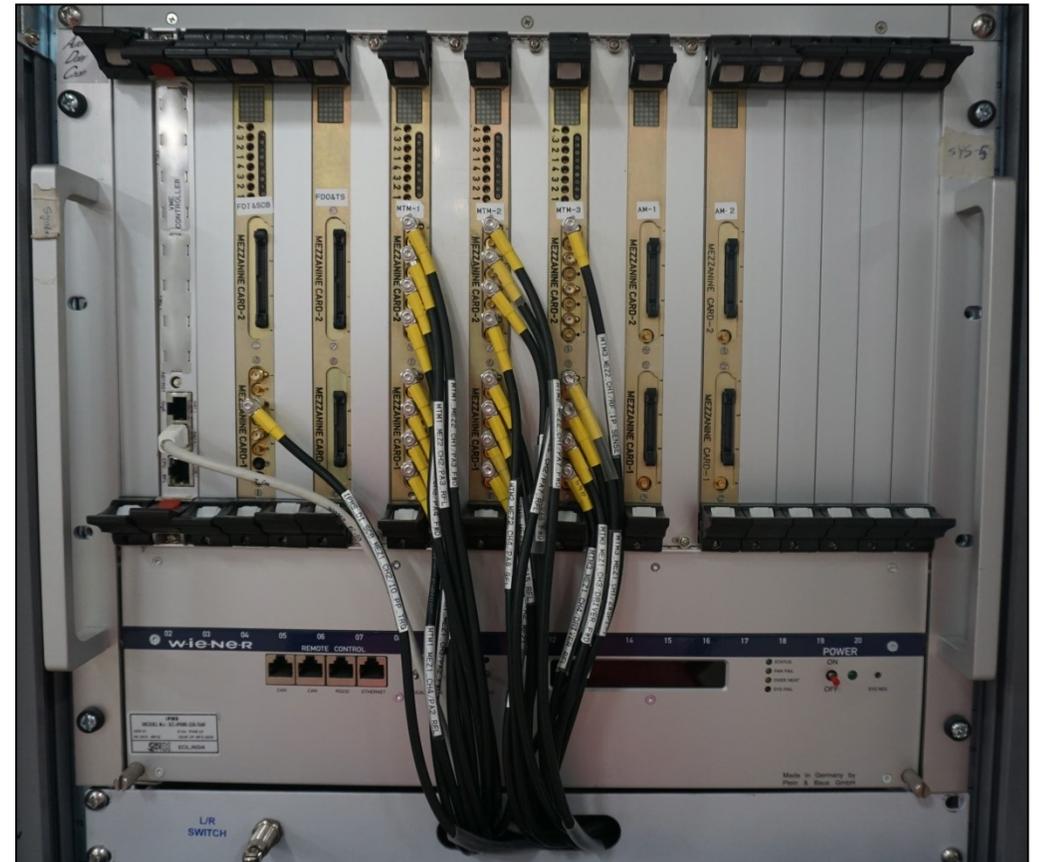
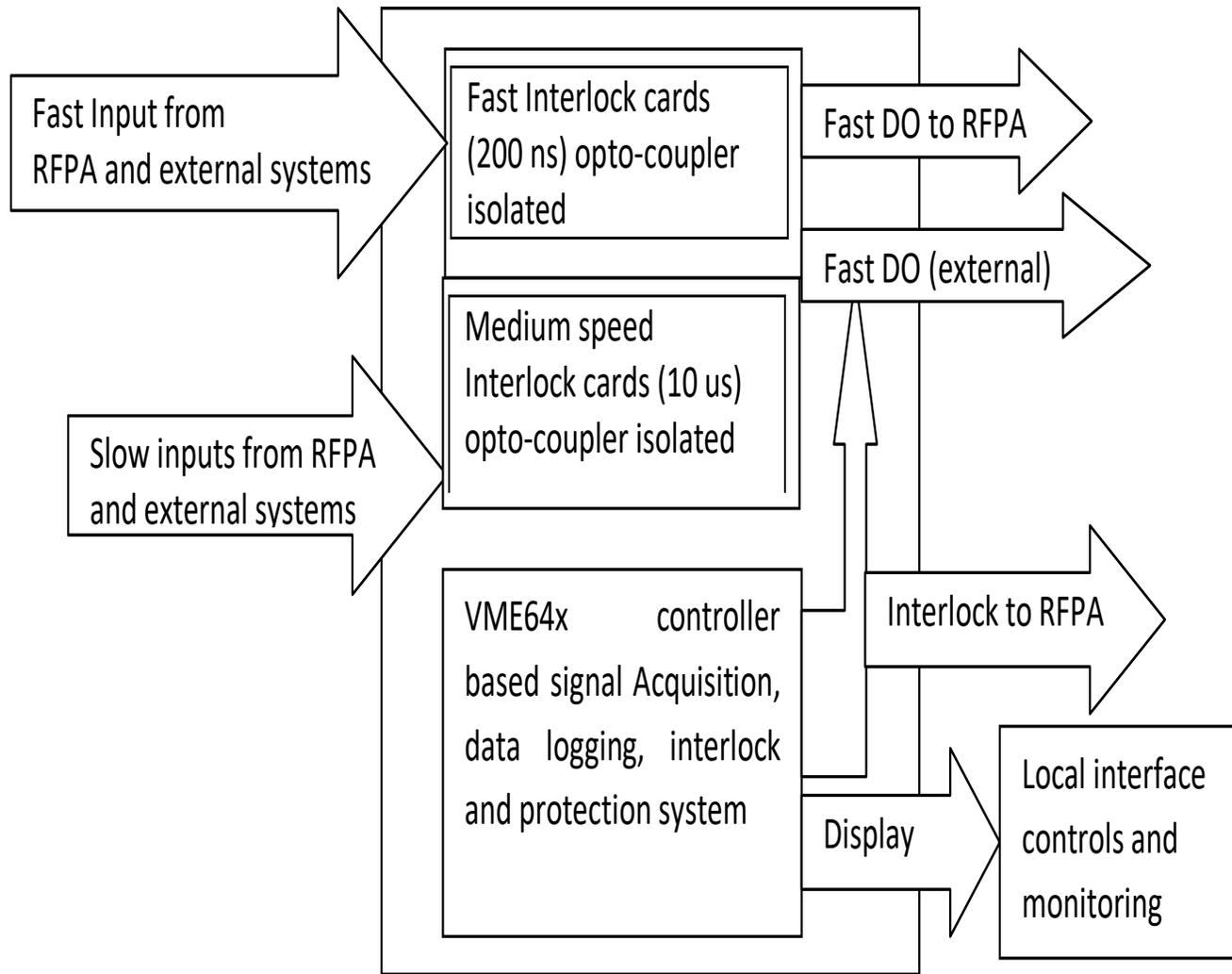
BARC has designed and developed Radio frequency power amplifiers (RFPAs). Under IKC, supplied nine numbers of 7kW, 325 MHz RFPAs via ECIL to Fermilab.

For PIP II Injector Test (PIP2IT) Facility of Fermilab, these RFPAs systems are being coupled to superconducting cavities of single spoke resonator 1 (SSR1), where it accelerates the particle beam passing through by giving them an RF energy with the appropriate phase.



Three SSA/RFP systems reached to Chicago / Fermilab





IPMS internal to stand alone 325 MHz, 7 kW RF Power Amplifier

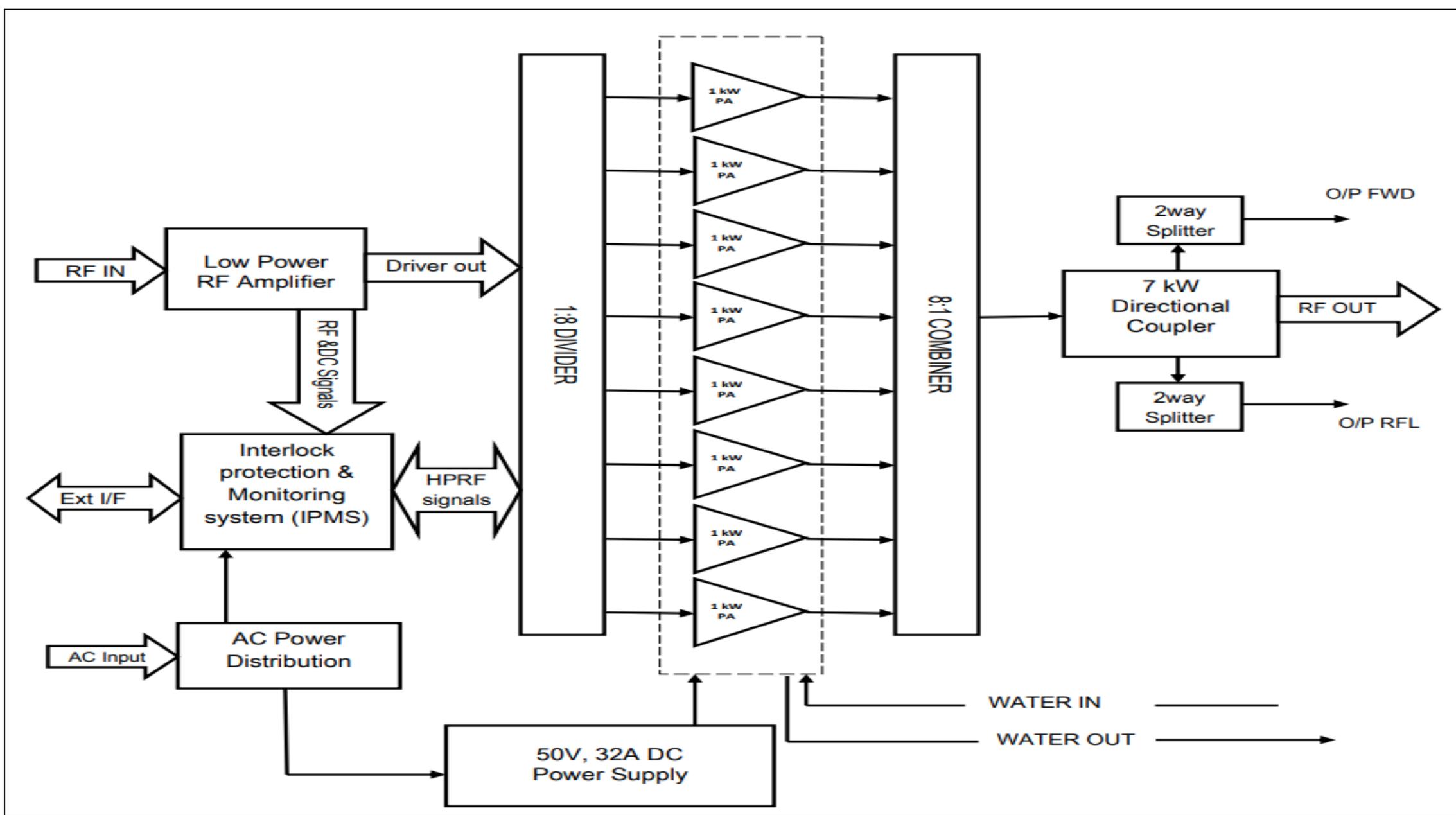
Current 325 MHz RF Amplifier system Information

1. MVME5500 as a controller is used in interlock, protection & measurement system (IPMS) of SSA. Controller has become obsolete now.
2. IPMS EPICS IOC containing old Linux kernel and toolchain for MVME5500 was used. We have only binaries available with us.
3. New IOC will be possible to develop quickly as the data base (db) files are available and device support can be easily developed.
4. All types of interfaces should be known prior. So, a comprehensive interface document is needed for all SSAs
5. Cavity wise RF power budget of accelerator should be known to maximize the operating efficiency of SSA
6. Overall Integration plan with other subsystems should be discussed well in advance

Suggestions

1. Common Interfaces with other sub systems in the entire accelerator chain
2. Availability of new technology of hardware and software need to be shared
3. Discuss overall scheme and logic
4. Uniformity in control
 - a. Hardware
 - b. Software
6. Obsolescence of hardware and software platforms should be considered well in advance
7. Open source platform should be used or accessibility to the platform should be ensured at institutions for smooth collaborative efforts
8. High end embedded system development i.e. next generation development - FNAL may suggest
9. A comprehensive system model of entire LINAC RF system (inclusive of accelerator cavity / SSA) can be made or shared (if available)

Thank you



System configuration / architecture of 325 MHz, 7 kW Solid State Amplifier (SSA) or RF Power Amplifier (RFP)