

# RF needs for SPL SC cavity tests

## HP-SPL modulators

21/1/2010

# Selected long-pulse modulators

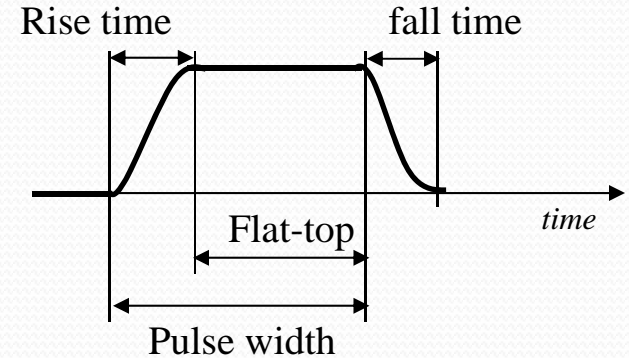
Facility	V <sub>peak</sub> (kV)	I <sub>peak</sub> (A)	Pulse-width (ms)	PRF (Hz)	P <sub>peak</sub> (MW)	P <sub>mean</sub> (kW)
Under construction						
LINAC <sub>4</sub> (LP-SPL)	110	50	2.1	2	5.5	23
XFEL	132	150	1.6	5	5.2	72
SNS	140	70	1.6	60	9.8	940
Future						
ILC	120	140	1.6	5	17	135
ESS	135	50	2	20	6.2	250
HP-SPL Teststand	110	30	2.1	50	3	350

*Preliminary figures*

# Modulators for LINAC4 (LP-SPL) (CERN)

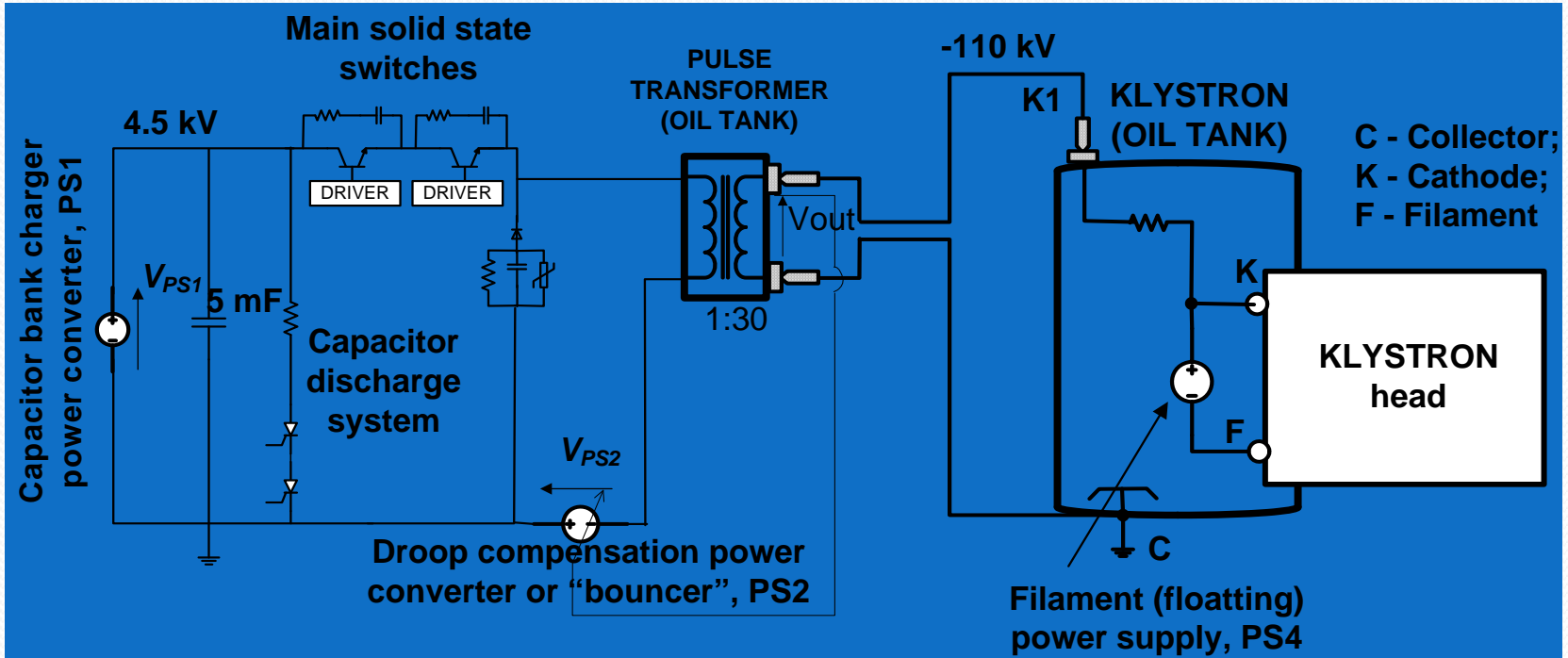
## Cathode power supply

- |                                  |                         |
|----------------------------------|-------------------------|
| - Pulse width:                   | 2.3 ms                  |
| - Flat-top duration              | 2 ms                    |
| - Rise/fall times (99% / 1%):    | 300µs                   |
| - Repetition rate:               | 2 Hz                    |
|                                  |                         |
| - Nominal voltage:               | 110 kV                  |
| - Nominal current:               | 50 A                    |
| - Nominal power (peak):          | 5.5 MW                  |
| - Average power:                 | 23 kW                   |
|                                  |                         |
| - Flat-top droop:                | < 1%                    |
| - HF ripple at flat-top:         | < 0.1%                  |
|                                  |                         |
| - Cooling:                       | Air (natural or forced) |
| - Maximum energy in case of arc: | < 20 J                  |



3MeV Teststand

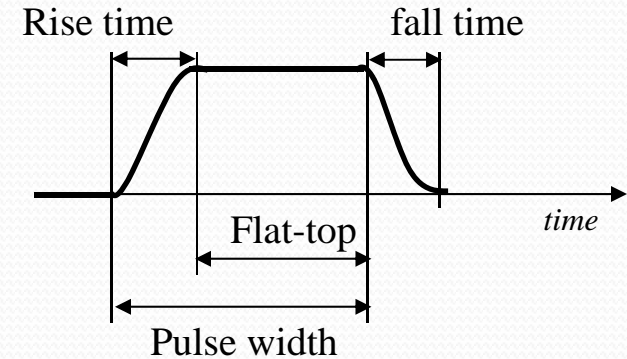
# Modulators for LINAC4 (LP-SPL)



# Modulators for SNS (LANL)

## Cathode power supply

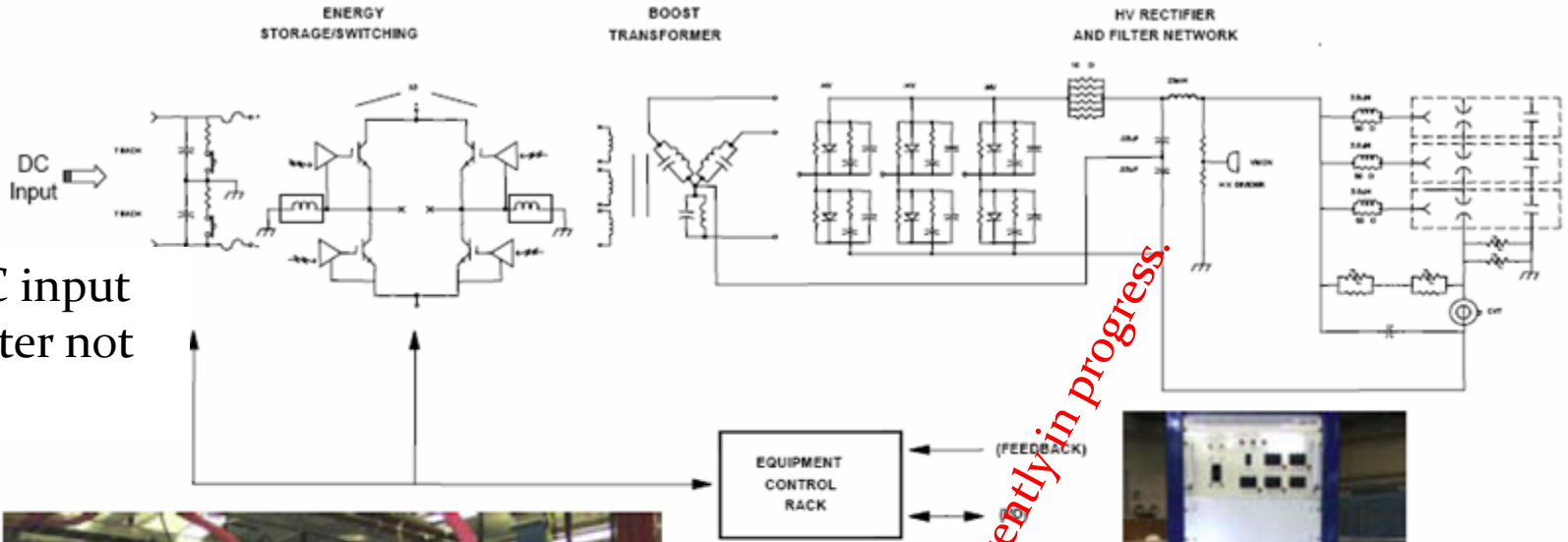
- Pulse width: 1.6 ms
- Repetition rate: 60 Hz
  
- Nominal voltage: 140 kV
- Nominal current: 70 A
- Nominal power (peak): 9.8 MW
- Average power: 980 kW
  
- Flat-top droop: < 1%
- HF ripple at flat-top: < 0.3%



**SCL-ME1 with 12 pack**

# The SNS modulator (LANL)

The Oak Ridge Nat Lab (SNS) type modulator, *Bill Reass and Al.* Los Alamos Lab



AC/DC input converter not shown



**High Voltage Converter Modulator**



**Equipment Control Rack**

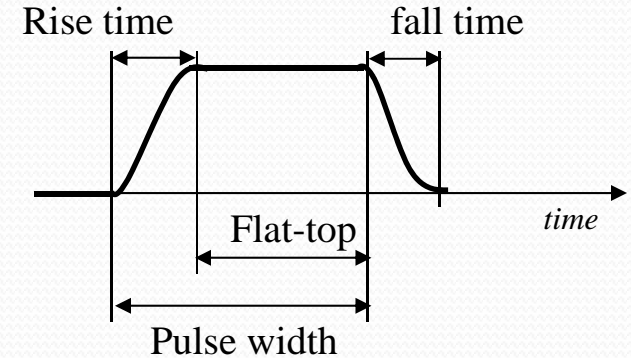
*Several reliability issues.  
New design of some parts currently in progress.*



# Future Modulators for ESS

## Cathode power supply (2 cavities/klystron preliminary values)

- Pulse width: 2.0 ms
- Repetition rate: 20 Hz
  
- Nominal voltage: 135 kV
- Nominal current: 50 A
- Nominal power (peak): 6.2 MW
- Average power: 250 kW
  
- Flat-top droop: < 3% ?
- HF ripple at flat-top: < 0.1% ?
  
- Cooling: Air (natural or forced)
- Maximum energy in case of arc: < 20 J





# Scandinova proposition for ESS modulator

## Observations

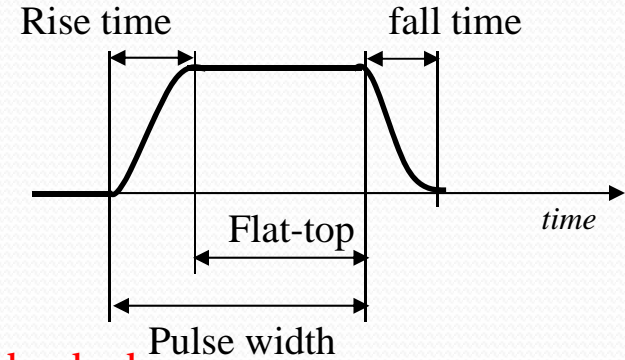
- The droop compensation proposed is with an LR filter – is there a reason for using this less efficient method (classically an LC ‘bouncer’ is used)?
- What is the volume of the droop filter (L and R) and additional 2mF filter capacitors? Has this been included in the mechanical models?
- It is difficult to match the mechanical models provided to the proposed design (dimensions would be useful).
- What possibilities are there for splitting the modulator/klystron assembly to aid integration?
- Has consideration been given to the transformer reset (and hence maximum reverse voltage)?
- What energy is deposited into the klystron in the event of an arc?
- What precautions are taken to ensure a switch does not fail during an arc, thus depositing the 2.9kJ of module capacitor energy?



# Future Modulators for HP-SPL Teststand

## Cathode power supply Preliminary specification

- Pulse width: 2.4 ms
- Flat-top duration: **2.1 ms**
- Rise/fall times (99% / 1%): 300µs
- Repetition rate: 50 Hz
  
- Nominal voltage: 110 kV
- Nominal current: 30 A
- Nominal power (peak): **3 MW**
- Average power: 360 kW
  
- Flat-top droop: < 5% (1%)
- HF ripple at flat-top: < 0.1%
  
- Cooling: Air (natural or forced)
- Maximum energy in case of arc: < 20 J



**Needs to be checked**

**Assumes 1.5 MW klystron with 50% efficiency**

**The effect on RF power should be evaluated to find an optimum (1% is a typical design objective).**

# CERN Modulator Requirements

- CERN is currently constructing the first of 15 LINAC<sub>4</sub> modulators
- Many modulator projects dealing with high power levels, such as that required for HP-SPL, have experienced difficulties in their realization
- CERN must further develop competence in high-power modulators that are compatible with future accelerator requirements

# HP-SPL Teststand

- The CERN Electrical Power Converter group is starting a 1-year study on high-power modulators
  - Appropriate modulator technologies will be proposed
  - Detailed design of critical sub-systems will be made
  - Prototype evaluation of key sub-systems will be made
- Objectives
  - Propose a well evaluated technical solution for the HP-SPL modulators
  - Provide estimates of cost, volume and other pertinent data
  - A working modulator could be envisaged for ~2014