LLRF requirements/issues for DRFS

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Outline

- Three important requirements concerning LLRF:
  1. LLRF feedback overhead (nominal ~15%)
  2. Gradient flatness of each cavity for near-quench-limit operation (5%?)
  3. Pulse-to-pulse stability of each cavity for luminosity operation (~1%)
- Tolerance of Pk, Ql and detunings to satisfy these requirements are considered.

- Cavity control schemes are compared (for DRFS):
  1. PkQl control: set rf power ratio and external Q (Qls) so that cavity gradients become flat at specific beam current.
  2. Cavity grouping: select same performance cavities and operate at the same gradients.
- DRFS will adopt “cavity grouping” because of
  1. Elimination of circulators (This requires same gradient operation.)
  2. Saving of rf power (PkQl control requires 14% additional power since the cavity Qls are not matched to beam loading.)
- Some ideas to operate 38 MV/m (at cavity grouping) are also shown.

Power Overhead

- Static rf losses (use the rf overhead at all times)
  - Klystron HV ripple (1% HV ripple -> 2.5% rf power)
  - Ql tolerance
  - Pk distribution tolerance
  - Pre-detuning of each cavity (~2% rf power)
  - Distribution of pre-detunings
  - Reflection power (in case of the PkQl control, ~14% rf power)

- Dynamic rf losses (used by the feedback control)
  - Klystron HV fluctuation
  - Beam current fluctuation
  - Dynamic detuning (microphonics+ Lorentz force detuning)

These issues will be covered by the llrf overhead. If the overhead is not enough the regulation of the rf fields will not satisfy the requirements

LLRF control at DRFS

- PkQl control: additional 14% rf power is required when 2 cavity operation with 25MV/m and 38 MV/m. Need circulators and variable Ql, Pk.
- Cavity grouping: no additional power is required. But need to examine the driving of cavities at 38 MV/m.

-> We will adopt cavity grouping and propose some ideas to drive 38 MV/m cavities at small overhead.

Simulation results

		RDR	DRFS (PkQl)	DRFS(Cavity grouping)
RF power	Operation gradient	Max. 33 MV/m	Average 31.5 MV/m	Max. 38 MV/m
	RF source	10 MW		800 kW
	Waveguide loss	8% power	2% power	2% power
	Static loss (Ql, Pk)	2% power	2% power	2% power
	Kly Hv ripple	2.5% power	2.5% power	2.5% power
	Microphonics	2% power	2% power	2% power
	Reflection	0% power	14% power	0% power
	Other LLRF margin	10% power	10% power	5%~10% power
Tolerance	Ql tolerance		3% (2)	3% (2)
	Pk tolerance		0.2dB (2)	0.2dB (2)
	Detuning tolerance		15Hz rms(3)	20Hz rms (3)
	Beam current offset		2% rms (3)	

(1) LLRF overhead ~5%
(2) Cavity gradient tilt (repetitive) ~5%
(3) Pulse-to-pulse gradient fluctuation ~1%rms

- We have to examine these numbers experimentally.
- Tolerance should be discussed with cavity and HLRF group. If the tolerance is smaller, better gradient tilt would be possible.