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RFQ Resonance Update

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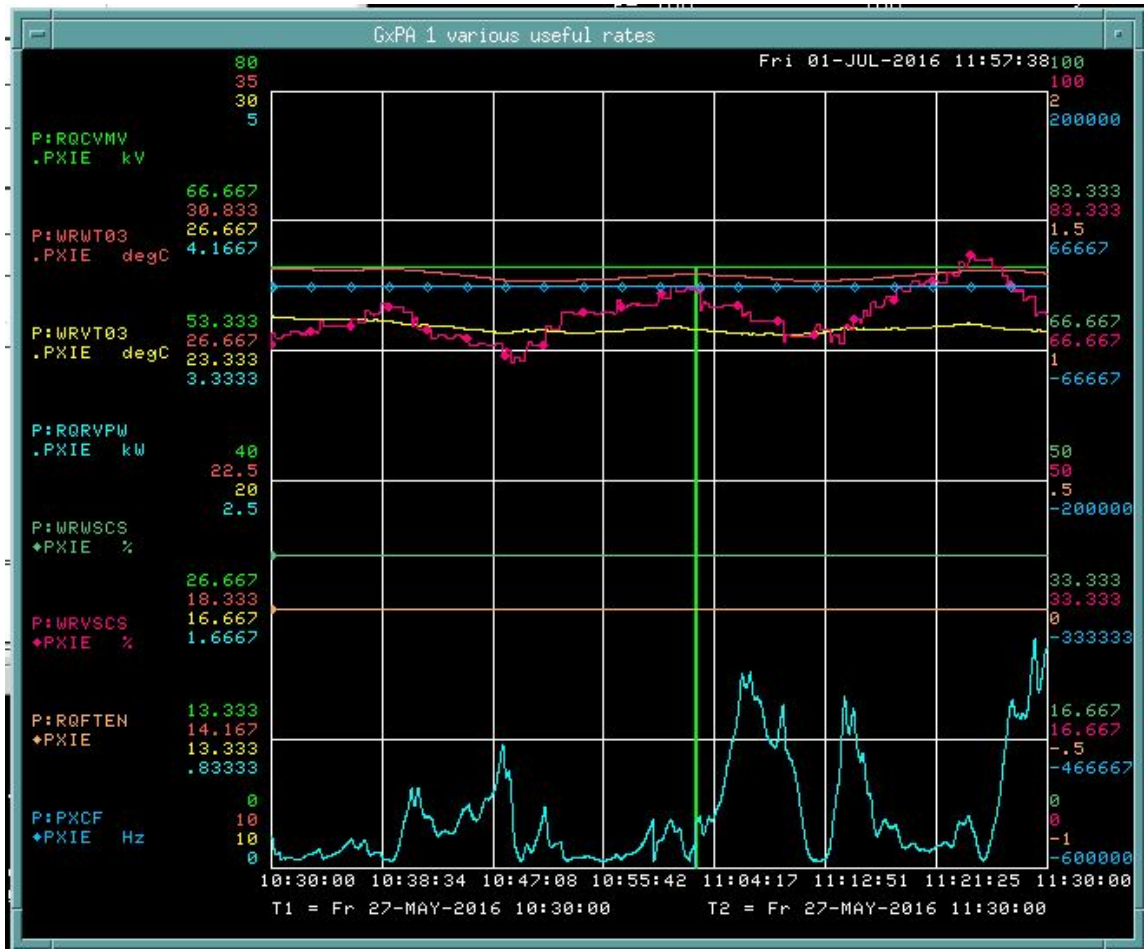
RFQ RF Quick Status Update

- RFQ successfully conditioned up to 5% duty cycle in pulsed RF mode.
- Hardware for resonant control system (mostly water distribution system) has been successfully commissioned.
- Pulsed RF operation is thermally stable when water system is regulating to a fixed temperature.
- RFQ conditioned in CW mode up to 63kV of field strength.
- So far, no signs failure in RFQ amplifier slices.
- Studies were performed on resonant control system in CW mode.

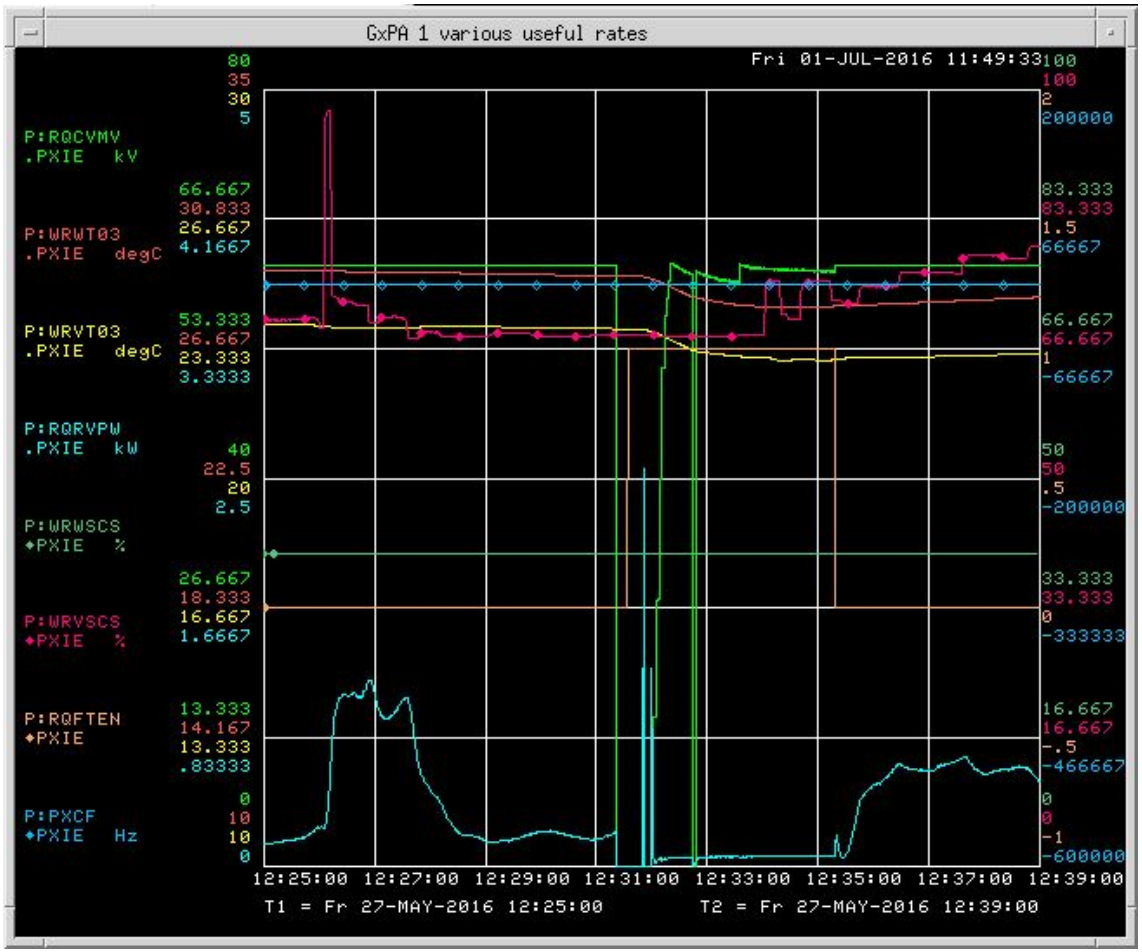
RFQ CW Operation Studies

- Plot on right shows an hour of RFQ CW operation with LLRF system holding frequency at 162.5 MHz.
- RFQ wall cooling water temperature was held fixed, while vane cooling water temperature was manually tuned to minimize reflected power.
- To maintain 5°C differential temp, vane valve must be almost fully open (~70%).
- A single, quick spark had little effect on stable operation.



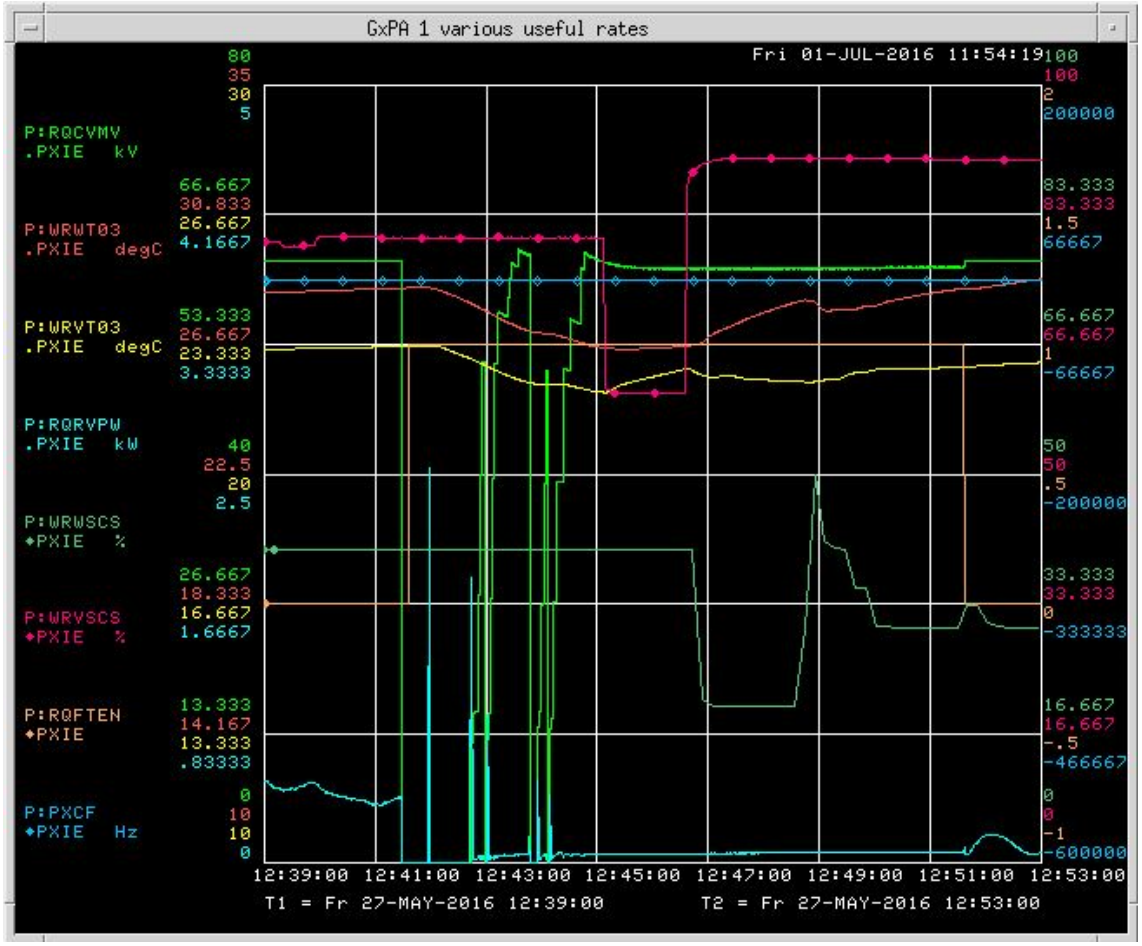
RFQ CW Operation Studies

- The plot on the right shows RFQ CW operation effect of about 40sec interruption in RF Power.
- LLRF system manually changed to frequency tracking mode.
- Field level stabilized after about 4 minutes with manual tuning.
- Thermal history continues well beyond establishing stable RF field.



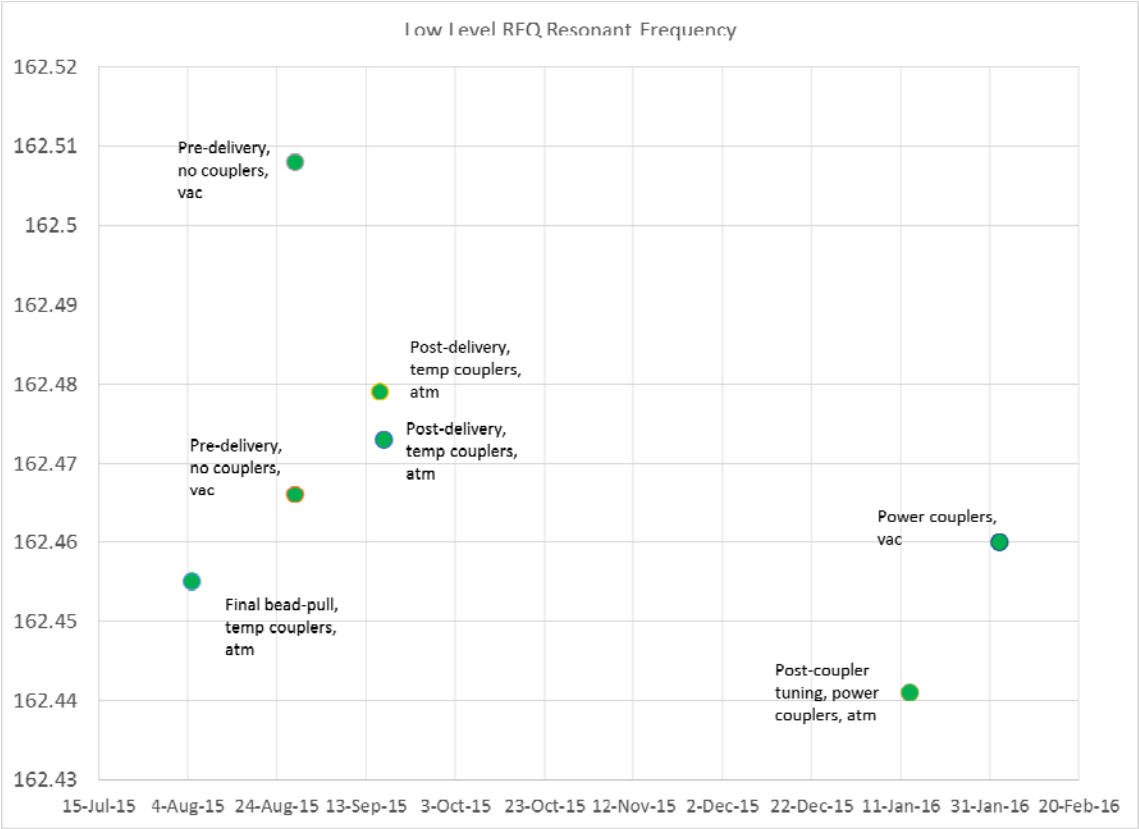
RFQ CW Operation Studies

- The plot on the right shows RFQ CW operation effect of about 100sec interruption in RF Power.
- Field level stabilized after about 10 minutes with manual tuning.
- Vane valve opening reaches limit and wall valve operation required to recover more efficiently.
- Field recovery time within spec with manual tuning (<10 x trip time).
- Larger range for vane cooling valve would be helpful.



Resonance Frequency Offset

- Operational resonant frequency ~60kHz lower than expected.
- Difficult to discover source of error from points where frequency was verified (right plot).
- Possibly due to recording errors and undocumented instrument or environmental factors.



Possible Reasons for Frequency Offset

- Errors in calculating thermal effect (confirmed and a potential source of 20kHz of error).
- Unforeseen motion due to atmospheric pressure under vacuum.
- Unforeseen effect of input coupler perturbation on resonant frequency.
- Resonant frequency highly sensitive to mechanical disturbance. Difficult to maintain repeatability after modifications.

Plans for Resonant Frequency Offset Diagnostics

- Sensing loop calibration
  - Prepare RFQ for direct network analyzer measurements.
  - Verify stability of sensing loop response over time and handling.
  - Measure sensing loop response of all loops directly out of RFQ.
  - Repeat sensing loop response measurements through switch tree (to speed up further measurements).
- Vacuum test
  - Compare sensing loop calibration and resonant frequency change for RFQ going from vacuum to atmosphere.
- Input coupler test and modification
  - Remove input couplers and check sensing loop calibration and resonant frequency with temporary input couplers.

Plans for Resonant Frequency Offset Diagnostics

- Perform input coupler modifications.
  - Fix air leak between DC block and coupler.
  - Retract coupling loop from RFQ with offset insert.
  - Retune input coupler coupling factors.
- Verify sensing loop calibrations and resonant frequency after modifications.
- Verify again, after pumping down RFQ.

- Analyze data to see if any particular point had a strong effect on the RFQ resonant frequency and if there are clues to the location of the field perturbation.