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et en physique des particules

Novel Scheme to Tune RF Cavities using Reflected Power

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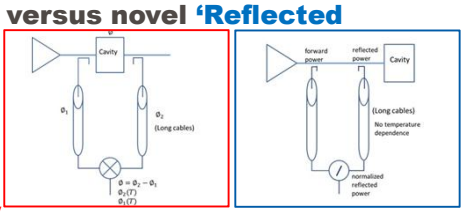
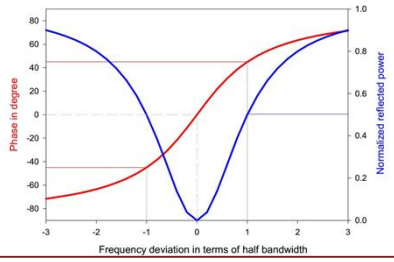
Abstract

Tuning of the natural resonance frequency of an RF cavity is essential for accelerator structures to achieve efficient beam acceleration and to reduce power requirements. Typically, operational cavities are tuned using phase comparison techniques. The phase measurement is subject to temperature drifts and renders this technique labor and time intensive. To eliminate the phase measurement, reduce human oversight and speed up the start-up time for each cavity, this paper presents a control scheme that relies solely on the reflected power measurements. A sliding mode extremum seeking algorithm is used to minimize the reflected power. To avoid tuning abrasion, a variable gain minimizes motor movement around the optimum operating point. The system has been tested and is fully commissioned on two drift tube linear accelerator tanks in TRIUMF's ISAC I linear accelerator. Experimental results show that the resonance frequency can be tuned to its optimum operating point while the start-up time of a single cavity and the accompanied human oversight are significantly decreased.

Conventional 'Phase' tuning versus novel 'Reflected power' tuning

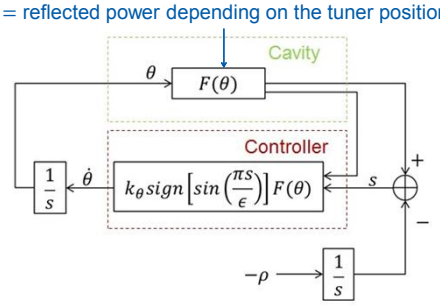
- **Phase:**
  - Linear function within the bandwidth
    - Allows classical tuning methods
  - Phase measurement influenced by environmental temperature
  - Temperature affects tuning accuracy
  - Manual adjustment required
- Reflected power:
  - Nonlinear function
    - Requires nonlinear tuning method
  - Reflected power measurement not influenced by environmental temperature
  - Higher tuning accuracy
  - Human oversight not required





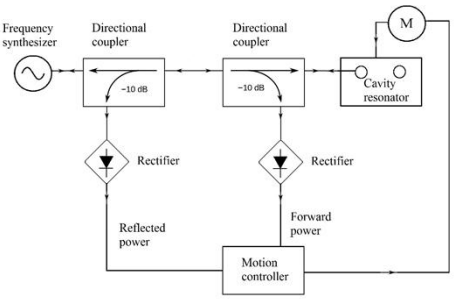
Sliding mode extremum seeking algorithm and system commissioning on TRIUMF's DTL tank 5

$F(\theta)$ = reflected power depending on the tuner position θ



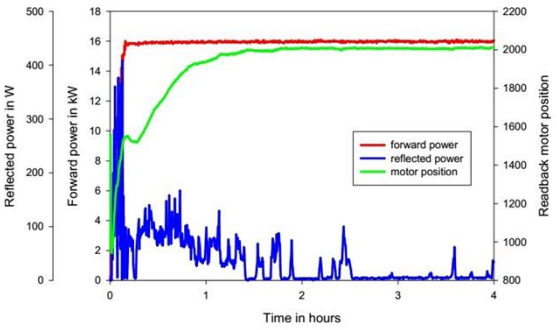
Sliding mode extremum seeking block diagram

- Algorithm implemented on TRIUMF's DTL tank 5
- Tuner speed $\dot{\theta}$ dependent on the reflected power
  - Movement stops when reflected power reaches optimum operating point
- Motion controller implemented into Galil motion controller
- Mechanical tuner setup adopted from previous phase based measurement system



Block diagram of tuner setup

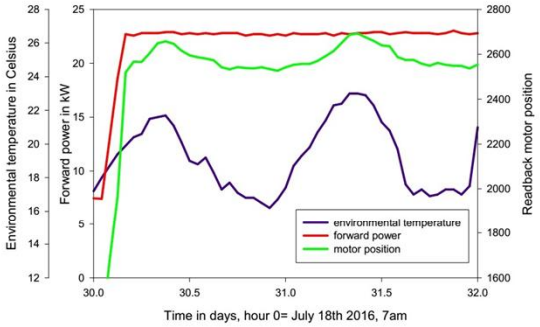
Tuning Results



- Reflected power minimized
- Tracks frequency shifts
- Eliminates environmental temperature influence
- Eliminates human oversight

- MRC200-TCOM coax cable
- 50m length
- 106MHz frequency signal
- $\Delta T = 20°C$

$\varphi_{error_c} \approx 15°$
+ amplifier induced
φ_{error_a}



CONCLUSION

The test results show that a tuning system based on reflected power measurements and the proposed sliding mode extremum seeking algorithm can track the operating frequency and provide optimal operating performance without using phase information and the accompanied manual adjustment. Labour hours connected to the traditional phase comparison technique can be drastically decreased while optimal performance in the long run is guaranteed, as the reflected power measurements are not affected by environmental temperature variations.

References

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