

Electrostatic drive for Advanced LIGO: an update

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Goals and design

- peak force for acquisition >0.1 mN
- noise in science mode $<1e-15$ N/Hz^{1/2}

- good noise immunity
- physical constraints
 - 95 mm radius CA
 - reaction mass size
 - gap 5 mm
- Design extrapolated from GEO design
 - slightly more force/V
 - similar voltage range

Drive

- 4 quadrants
 - longitudinal/pitch/yaw control
 - common bias electrode
 - interleaving fingers/combs with 5 mm pattern scale (equals gap)
 - additional weak-coupling common bias electrode
 - 3 to 10% of the coupling (TBD)
 - matches electronics dynamic range to smaller force range

Electronics

- Use 800V pk-pk devices (Gain 40)
 - believed reliable
 - compact if water cooled
 - allows AC bias
 - 180 dB 1Hz dynamic range demonstrated
- With low gain mode (80V pk-pk)
 - 10x less gain
 - 10 dB less dynamic range
 - probably more nearly obtained in practice with noise from up-stream electronics

Options (digitally selectable)

- A. Maximum force ($450\mu\text{N}$)
 - acquisition
 - strong-coupling electrodes driven by up to 400V
 - noise $2\text{e-}13$ N/rtHz
- C. Weak coupling, high voltage ($45\mu\text{N}$)
 - noise $2\text{e-}13$ N/rtHz
 - comissioning?
- D. Weak coupling low/high voltage ($4.5\mu\text{N}$)
 - noise $5.6\text{e-}15$ N/rtHz
 - close to design sensitivity but not quite, strong
- E. Weakest drive (450 nN)
 - equivalent to 68W photon drive
 - noise $5.6\text{e-}16$ N/rtHz
- see T060006-00-K for more detail

Notes

- Noise will be higher
 - differential inputs, whitening filters etc.
 - probably significant in high-voltage mode
 - less so (few dB?) in low-voltage mode
- Useful range is less
 - the range given is for a uni-polar square-law force
 - linearisation will reduce range
- Estimated requirement for science mode noise is $\sim 4e-15$ N/rtHz (very very rough)