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 (450μN)
  - acquisition
  - strong-coupling electrodes driven by up to 400V
  - noise 2e-13 N/rtHz
- C. Weak coupling, high voltage (45μN)
  - noise 2e-13 N/rtHz
  - comissioning?
- D. Weak coupling low/high voltage (4.5μN)
  - noise 5.6e-15 N/rtHz
  - close to design sensitivity but not quite, strong
- E. Weakest drive (450 nN)
  - equivalent to 68W photon drive
  - noise 5.6e-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 ~4e-15 N/rtHz (very very rough)