Overview of Motion Control on the KAT-7 and MeerKAT Radio Telescopes

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Photo: SKA South Africa

KAT-7 Radio Telescope

KAT-7

- Prototype/pathfinder for MeerKAT
- 7 antennas with approx. 15m main reflector diameter
- Elevation over azimuth movement
- Azimuth movement via motor driving gear in pedestal
- Elevation movement via jack screw

Photo: SKA South Africa

Technical Challenges

- Adapting drives designed for *CNC* machines. Issues with encoder startup reference caused by position slip during shut down.
- The synchronization to *NTP* required special development.
- Adapting controllers for continuous operation. Issues with unexpected controller reboots caused by buffer overflows.
- Composite reflector accuracy.

Lessons learned

- Time spent re-coding or changing development
- Better simulators for smoother integration
- ICD and requirements for concurrent development

Photo: SKA South Africa

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MeerKAT Radio Telescope

Motion Control on Radio Telescope

- Moving yoke structure on static pedestal
- Elevation over azimuth movement
- Multiple receivers mounted on rotating platform (receiver indexer)
- Precision target tracking
- Fast slewing between targets
- Continuous operation

Photo: SKA South Africa

Technical Challenges

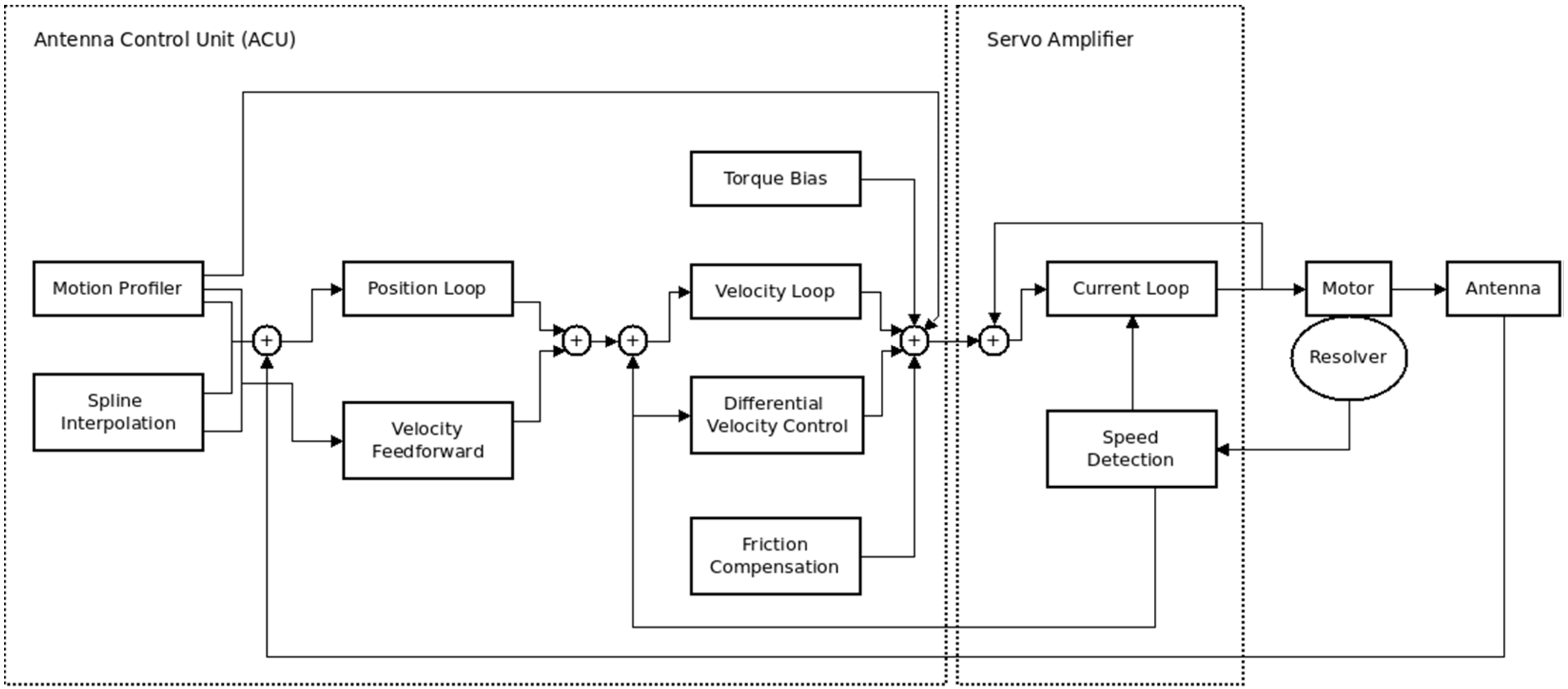
- *EMI* measurement - defining new test methods
- EMI mitigation
- Maintaining *EMI* performance through manufacture
- Unit testing (e.g. gearbox control)
- Modification to standard software (e.g. Servo Computer)
- Concurrent development

Lessons Learned

- Testing improvements
- Effect of installed receiver
- Equipment testing in operational environment

Servo Control System

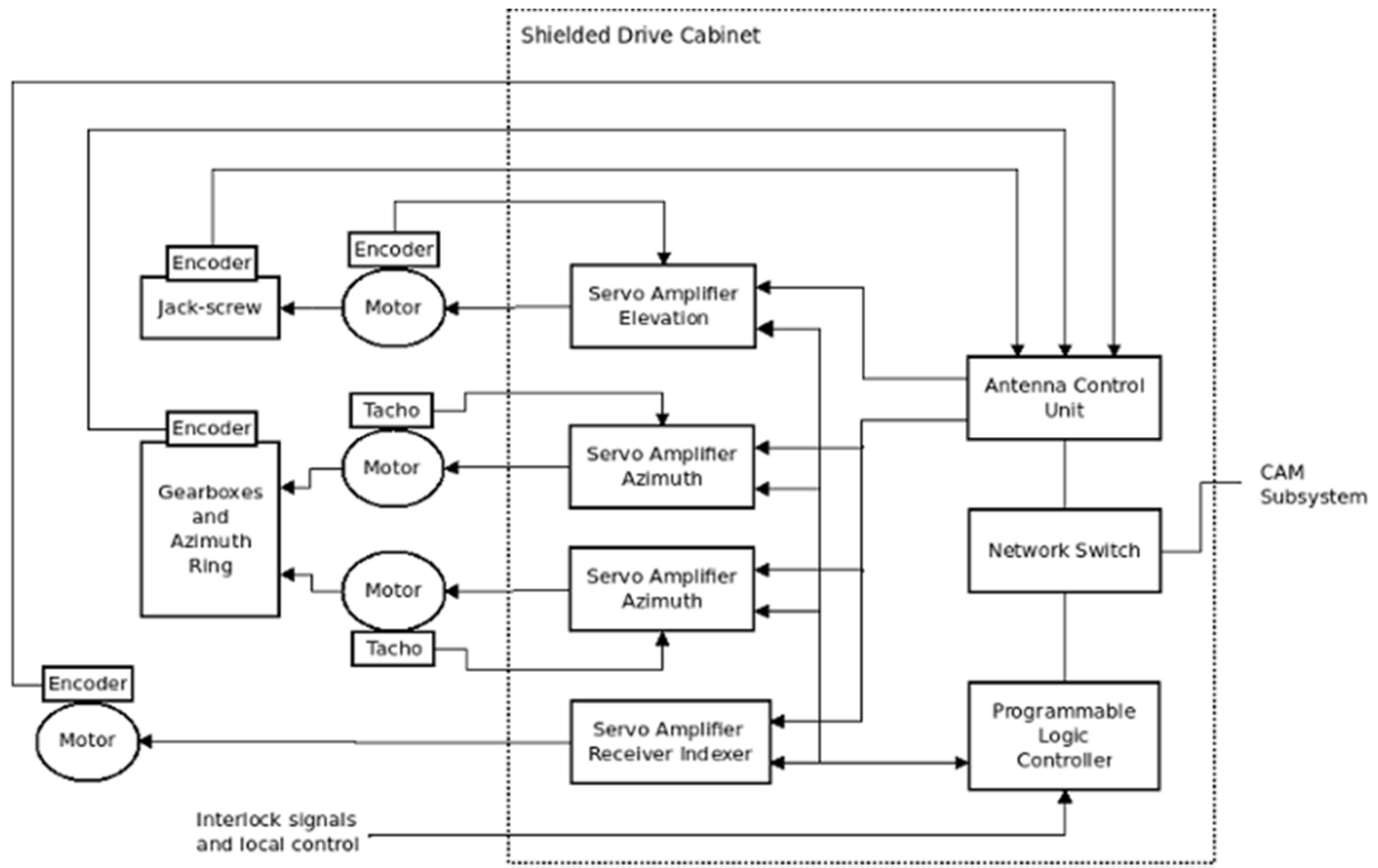
- Similar to *ALMA* radio telescope
- Controlled by a Servo Computer (*ACU*)
- *ACU* coordinates actions within the servo system and interfaces to *CAM* and *PLC*
- Digital Control Loop
- *PLC* interfaces with safety interlocks



Overview of Telescope Control Loops

Antenna Control Unit (Servo Computer)

- *CAM* link via Ethernet *TCP/IP* interface using *KATCP* protocol
- PC-based system with industrial components
- Uses VxWorks 6.9 real time operating system
- Implements optional pointing error model
  - Systematic errors
  - Deformation due to wind and temperature (tiltmeter)
  - *RF* refraction using weather data
- Time synchronized with Precision Time Protocol (*PTP*)



Overview of Servo System

Servo Drive System

- Totally enclosed, non-ventilated brushless motors
- 2 azimuth motors, electrically torque biased
- Elevation drive system - ball screw and torque servo motor
- Receiver Indexer - between operations the motor is disabled, brake engaged (no current) and encoder readout is discontinued to reduce potential *EMI*

Encoder Subsystem

- Absolute optical encoders mounted directly ‘on axis’.
- Safety interlocks hard wired (in the event of *PLC* malfunction)
- *PLC* tasks:
  - Handling of drive system interlocks and safety functions
  - Handling of travel range limits independently from *ACU*
  - Warning functions (horn and light)
  - Low level drive control of drives from portable control unit *(PCU)*
  - Communication to *ACU*
  - Tiltmeter readout

Electromagnetic Interference *(EMI)*

- Servo Drive Compartment - shielded box containing servo computer and other radiating components
- Extension boxes to minimize *SDC* cable interfaces
- Motors and encoders in *EMI* shielded boxes with terminated shielded cables
- Data line filters used for monitoring lines, *PCU* inputs and control lines

Operating Modes

- Servo system receives azimuth and elevation coordinates
- *ACU* uses spline interpolation for tracks
- *ACU* applies motion profile for fast slewing
- *ACU* can also track with astronomical coordinates (right ascension and declination)
- Observation routines translated by a ‘proxy’ device
- Routines define various types of sky scans

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