Feed & Front End PDR

Monitor & Control

and

Cryogenics
The “Card Cage”
(Photograph)
The “Card Cage”

• Originated with X-band Receiver in 1980’s
• Different for each Receiver Band
• Hand-Wired
  • Labor Intensive & Mistake Prone
• Many components now obsolete or hard to get
• Mixes high voltage (150 VAC) & low-level signals (ie: LNA bias)
Old M&C
(for L, X, K & Q)
Current Monitor Points
(L, X, K & Q-Band)

- **Monitor Points:**
  - LNA $V_{\text{Gate}}$ (RF1/2 & LF1/2) & LED Voltage
  - Dewar Temperature (300, 50, 15°K Stages)
  - Vacuum Pressure (Dewar & Pump Line)
  - Cryo Status (Off, Cool, Stress, Heat, Pump)
  - Pump & Solenoid Valve Status
  - AC Current
  - Rx Band ID, S/N & Mod Level (4+6+2 bits)
Current Control Points
(L, X, K & Q-Band)

• Control Points:
  • Cryo Status (Off, Cool, Stress, Heat, Pump)
  • Control LNA Bias Settings (with potentiometers)

• Signals that pass thru the Card Cage:
  • Lo-Cal Drive (TCAL)
  • Hi-Cal Drive (SCAL)
Current “Local” M&C Functions

- Monitor Dewar Temperatures & Vacuum
- Control Refrigerator and Vacuum Pump
  - based on monitored parameter
- Control LNA Bias Settings
- Communicate with Rest of World
  - For VLA, used F14 Module
  - For EVLA, via the MIB
New M&C Guidelines

- Minimize Digital “Traffic”
- Fail-Safe Design
- Replace Obsolete Components
- Minimize Space Required
- Standardize Components & Systems
Cryogenic and Vacuum Control

• Operating Sequence Controlled “Locally”
  – “Fail-Safe” if Computer is “Down”
    • Refrigerator will not start without vacuum in Dewar

• Current Design Works Well
  – Don’t change the basic logic
  – But do it in new hardware
“Stress” Mode and AC Current Monitor

• VLA has the capability to
  – Add “stress” heat load to refrigerator
  – Monitor total current to refrigerator and vacuum solenoids

• This was meant for remote diagnosis, but is not used
  – Cryo performance trends monitored instead

• This capability not needed for EVLA
Amplifier Biasing

• “Servoed” Bias Circuit
  – Maintains $I_D$ Constant by Varying $V_G$
  – Uses 8 pots to control 4 stages per card
  – Provides Buffered Monitor Voltages
  – Provides Over-voltage and ESD Protection

• Current Design Works Well
  – Don’t change the basic circuit design
  – But do it in new hardware
EVLA Receiver
M&C Options

1) A dedicated Card Cage for each receiver
   • “Old” Philosophy
   • Need 240 units + spare cards

2) Single M&C Rack Unit for all 8+ Rx’s / antenna
   • “New” Philosophy
   • Total of 30 units + spare cards

• Surely easier and cheaper to build 30 rack units
  than build/modify 240 Card Cages
Multi-Receiver M&C Unit

- Common Temp & Vacuum Monitoring
  - 4-wire DT-471 Temp Sensors good for cables many feet in length
  - Need to investigate maximum cable length Hasting DV-6 pressure sensors can handle (10-500 mV)

- Remote Fridge & Pump Control
  - Avoids 150 V / 60 Hz near sensitive LNA bias lines
M&C Computer

- Embedded Control Computer
  - How smart does the Rx μC need to be?
  - MIB or dedicated Front End Subsystem?
  - Engineering M&C and Diagnostic Software
  - Since no “Local” access, need identical units for Lab testing
New M&C Cards
Functions

- **New Temperature Sensor Cards:**
  - Cryo Temps : 2 per Rx times 8 = 16 (+spares)
  - Room Temps : 1 per Rx times 8 = 8 (+spares)

- **New Vacuum Sensor Cards:**
  - 2 per Rx times 8 = 16 (+spares)

- **New Control Card:**
  - Pump / Fridge sequencing and Heater On/Off control for each Receiver (ie: 8+)
New Amplifier Bias Cards

- Can be much smaller than old design
- Possibly mount inside Dewar
- Bias lines shorter, shielded by Dewar
- Fewer pins in Dewar feedthru connector
  (typically 9 lines required for a 4-stage LNA)
  - Cheaper
  - Better seal
  - Better RFI bypassing
New LNA Bias Card

- **LNA Bias Card (LBC):**
  - Minimum of 4 stages x 2 Polarizations = 8 stages
  - Sync Serial Interface to Rx M&C Unit
  - Programmable Drain Voltage and Current settings
  - Monitor all $V_{\text{Drain}}$ and $I_{\text{Drain}}$ settings plus $V_{\text{Gate}}$
  - Use NRAO-Tucson has a Quad LNA (16-stage) card?
    - (8-layer board, 800 cpts, 32 channel DAC SCLK, SYNC, DIN + VD/ID/VG-Mon)
  - Non-volatile Bias Settings?
    - (or controlled by a “remote” PIC micro like Quad LNA)
ALMA Quad LNA Bias Circuit

- All resistors are thick film SMD (0603), 1% unless specified otherwise.
- All capacitors are ceramic SMD (0603).

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Notes:
1. All resistors are thick film SMD (0603), it unless specified otherwise.
2. All capacitors are ceramic SMD (0603).
Monitor by Exception

- If go with minimum amount of processing power:
  - Instead of monitoring all the voltages, all the time
    - Each $V_G$ compared to its saved “OK” value
      - If all are OK, a monitor bit is “low”
      - If any are not OK, the bit goes “high”
  - For diagnostics, the MIB can cycle through and read back all voltages and currents on command
  - Bias voltages set by non-volatile “digital pots”
    - Could be changed, if required, at any time
  - But Cryo & Vacuum need continuous monitoring
Monitor Continuously

• If use a Rx μC with lots of processing power:
  – Monitor all the voltages, all the time
    • Each $V_D$, $I_D$ & $V_G$ compared to its saved value
      – Reload if “set” values are not correct
      – Catches instances where LBC card has lost power

• Provides processed data to an Engineering M&C
  Lap Top as well as Master Control Computer
  • Temp in°C, Pressure in microns, etc

• Can the MIB handle this?
Design Work

• Will need New Cards
  – Temperature, Vacuum, Control Boards
    • Straight forward - just update our existing design
    • Do more on less real estate
  – LNA Bias Card
    • New (or modified NRAO) design
  – Software
    • Depends on whether done in MIB or dedicate Rx μC

• May need to hire a new junior engineer?
Cryogenics
Refrigerator Drives

• The Refrigerator Motor on each Rx requires a 150 Volt, 2-Phase Supply
• We now derive the Second Phase using a R-C Network
  – Requires a separate “box” for each Front End
  – Requires “tuning” to get phase shift right
• Proposed Alternate: Scott Tee
Cryogenics
Scott Tee

- A Way of Connecting Two Transformers to derive 2-phase from 3-phase
- Smoother Drive Without Tuning
- Transformers Already In-House
- Mount in Module or Bin
  - Include Vacuum Pump Control, He Pressure Sensors, etc.
Cryogenics
Helium Compressor

• VLA currently has 2 compressors supplying 80 S.C.F.M. (total) to 5 refrigerators per antenna
• EVLA will need 120 S.C.F.M. for 8 refrigerators
• New compressors required
  • Testing of a higher flow compressor already started
  • Direct replacement
  • Cost – on the order of $350K