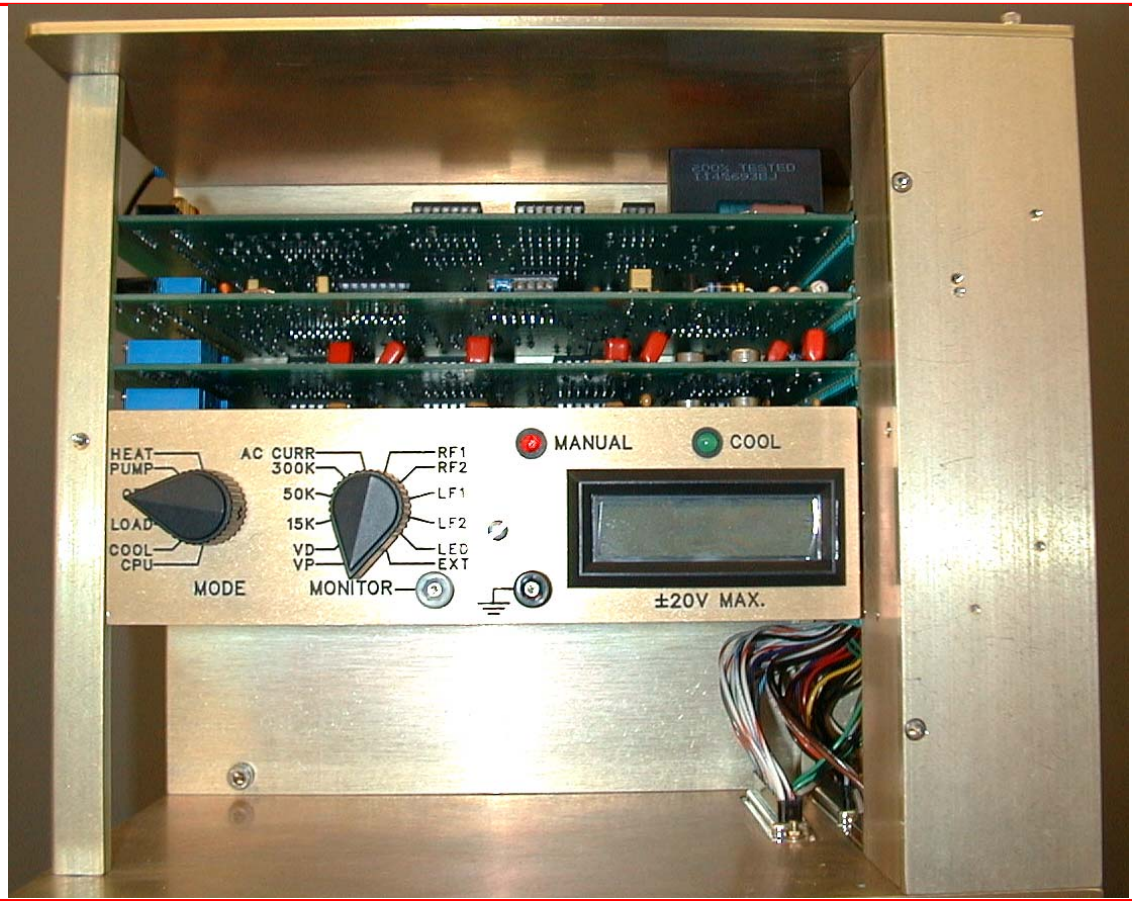
Feed & Front End PDR

Monitor & Control
and
Cryogenics

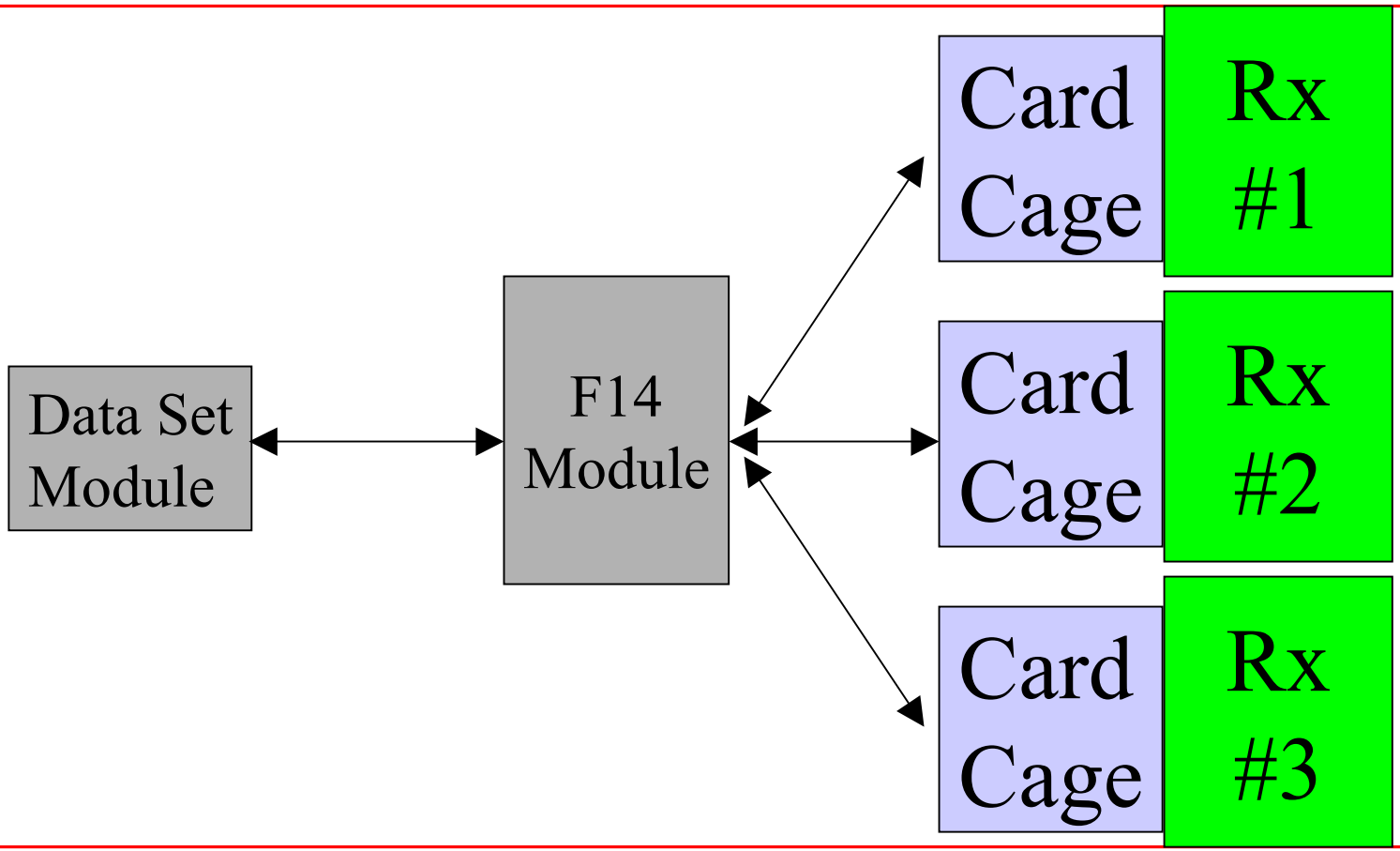
The "Card Cage" (Photograph)



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_{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

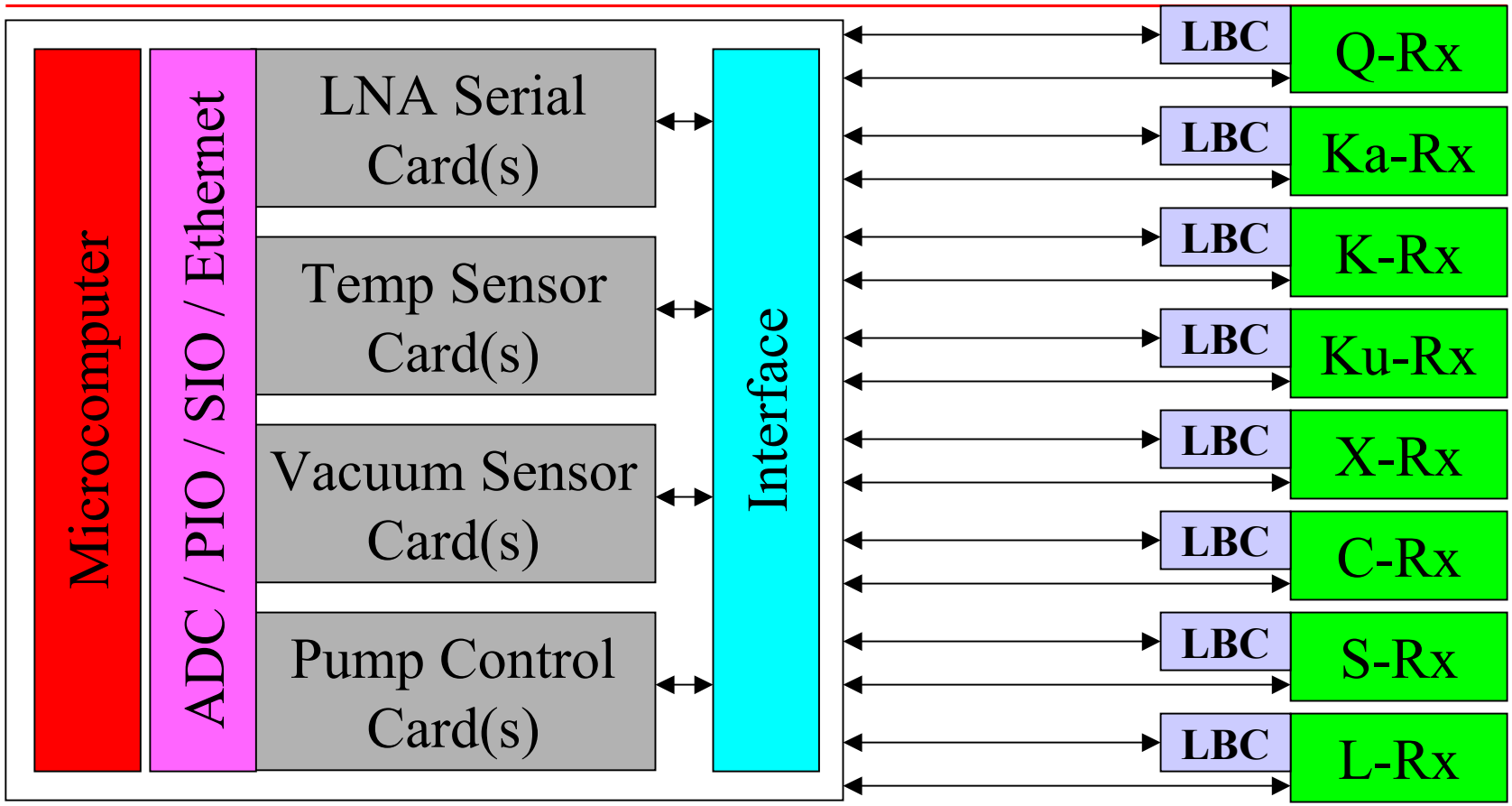
- Current Design Works Well
  - Don't change the basic circuit design
  - But do it in new hardware

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

New M&C Block Diagram



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+)

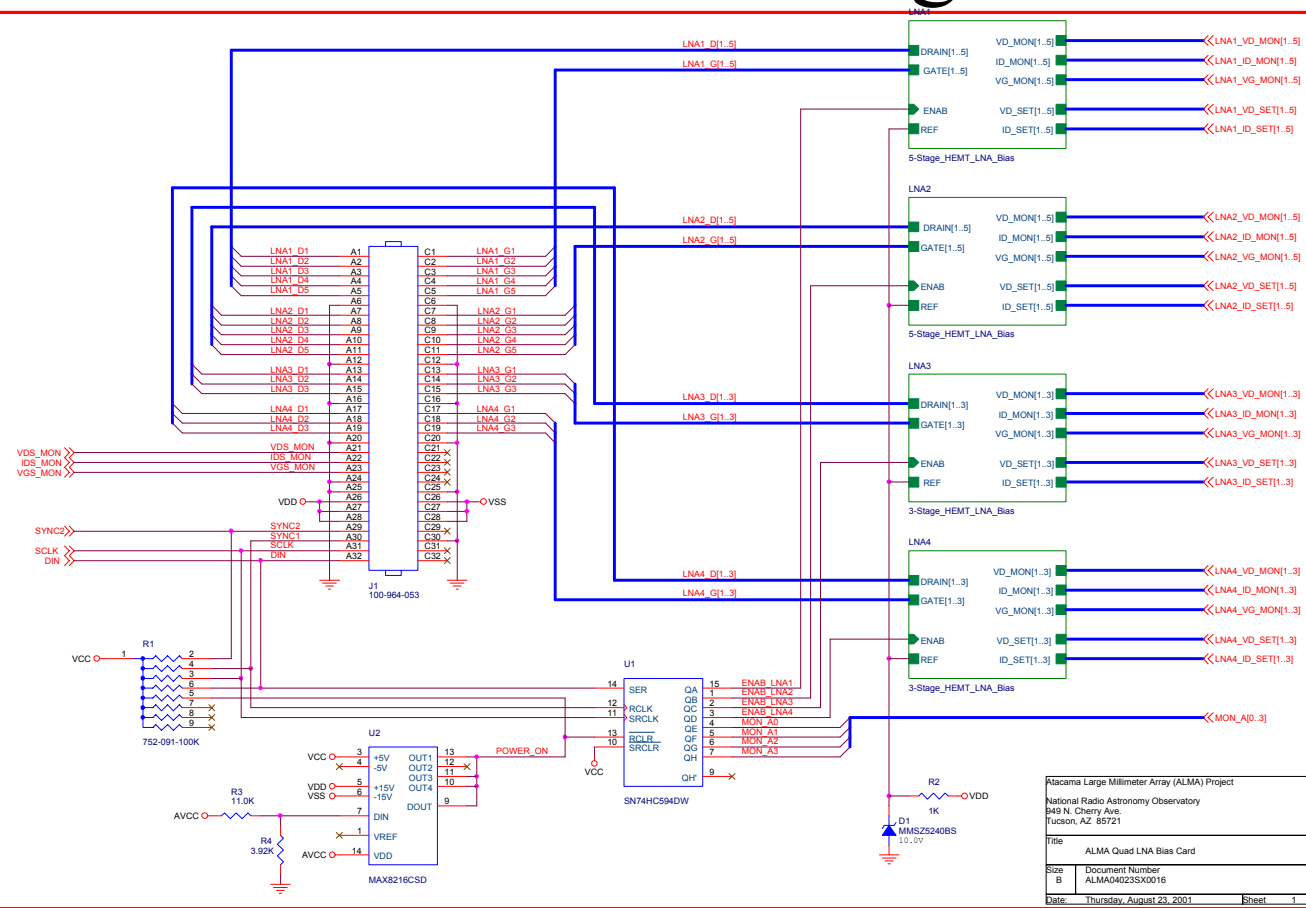
New Amplifier Bias Cards

- 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_{Drain} and I_{Drain} settings plus V_{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)

NRAO-Tucson
ALMA Quad LNA Bias Card Block Diagram



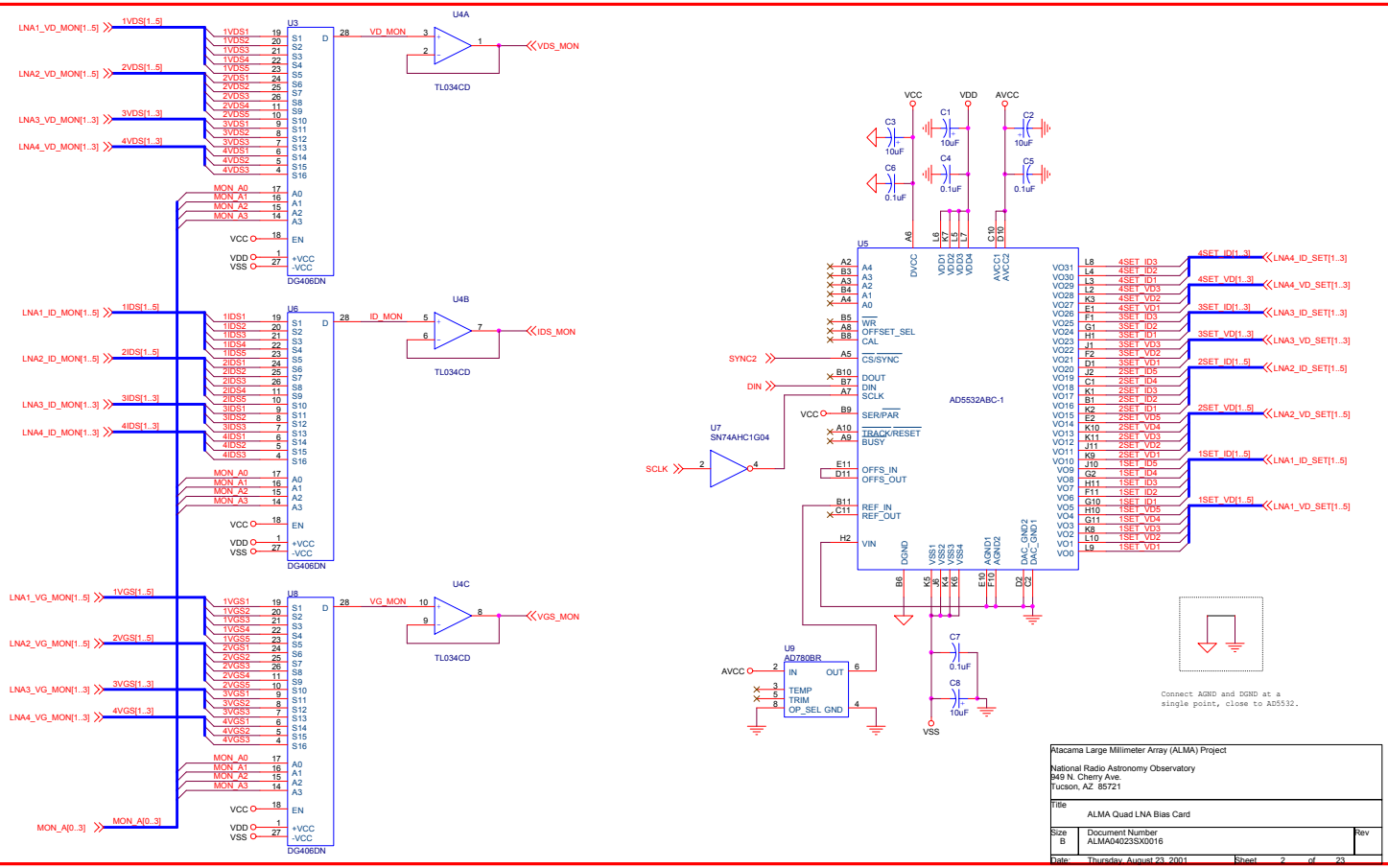
To 5-Stage LNA #1

To 5-Stage LNA #2

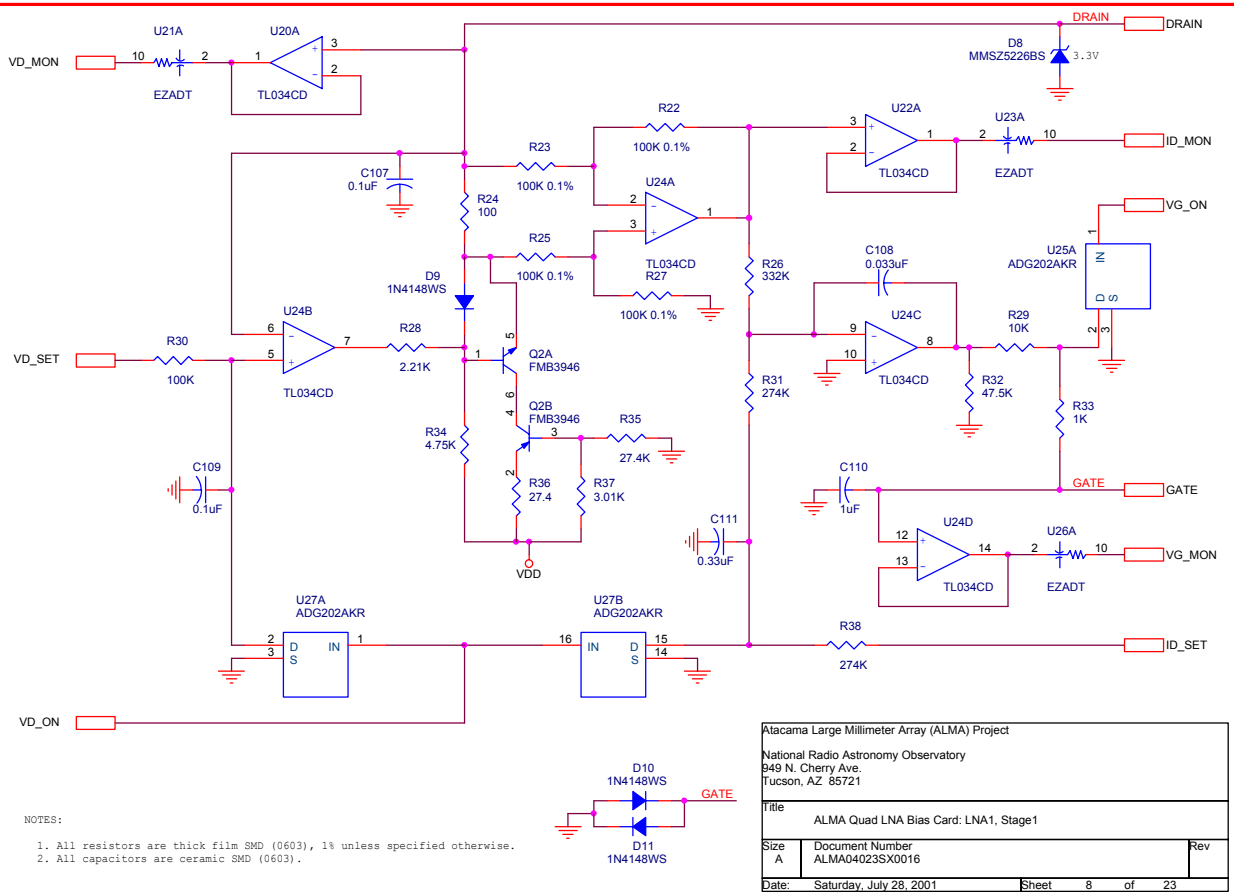
To 3-Stage LNA #3

To 3-Stage LNA #4

NRAO-Tucson
ALMA Quad LNA Bias Card Overview



NRAO-Tucson
ALMA Quad LNA Bias
LNA Bias Circuit



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