EVLA Project Book, Chapter 4

4 Antennas and Feeds

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Revision History:
2002-Feb-28, Rev C
Add paragraph on RFI; identify cable, tubing, and ducting routing in the vertex room as a system-engineering task; add paragraph on AC power budget and clean vs. dirty power; add paragraph about pointing improvements including plans and impact on EVLA; add paragraph on feed/receiver windows and radomes; add paragraph on moisture and corrosion control in feeds; add information concerning waveguide transitions between feeds and receivers;
2001-Nov-21, Rev B
Incorporated additional information and change requests from S. Srikanth that included resolving many TBD's in feed specification tables. Added revised antenna optics drawing.
2001-Oct-19, Rev A
Incorporated additional information and change requests from scientific liaisons (B. Butler, V. Dhawan, & M. McKinnon)

Summary:
One of the EVLA requirements is to provide continuous frequency coverage from 1 to 50 GHz. Optimized feeds and low noise receiving systems will be installed to provide the maximum possible G/T performance. This chapter describes the antenna modifications and new feeds required to achieve this goal.

4.1 Introduction

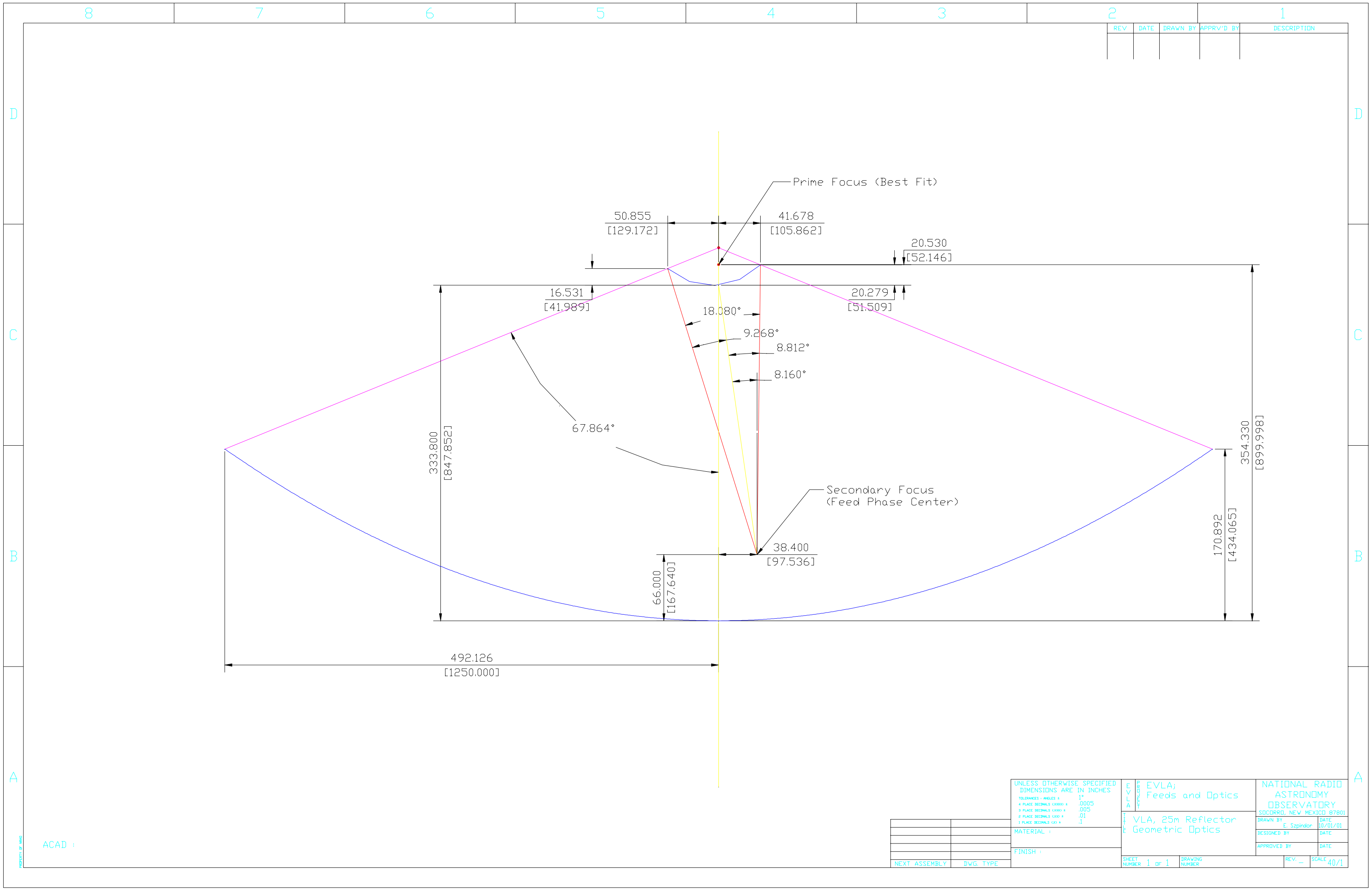
The VLA currently supports six cryogenic receivers. Gaps in coverage exist between bands. Continuous frequency coverage will be achieved by adding two new receivers (S- and Ka- Bands) and expanding the frequency range of the others.

The VLA uses twenty-eight, 25 m diameter, Cassegrain antennas. The EVLA will use the existing VLA primary and secondary reflectors without any changes.(1) Therefore, no requirements are presented below for the reflectors. However, a geometric description of the VLA optics will be useful in the specification and design of the EVLA feed cone and feeds. The geometric description is provided in Table 1 and depicted in Figure 1.

Table 1 VLA Optics(1)(2)

Parameter	Original VLA	Current VLA	EVLA
Primary Reflector diameter	2500 cm	no change	no change
F/D, Primary Reflector (best fit parabola)	0.36	no change	no change
Primary Reflector focal length	900 cm	no change	no change
Secondary diameter (long axis)	235 cm	no change	no change
Distance, Primary Vertex to Secondary Vertex	847.78 cm	no change	no change
Distance, Secondary Focus to Primary Vertex	167.64 cm	no change	no change
Distance, Best Fit Prime Focus behind Secondary	52.15 cm	no change	no change
Radius of Feed Circle	97.54 cm	no change	no change
Angle Between Primary Reflector Axis and Feed Axis	8.160°	no change	no change
RMS Surface Accuracy	0.07 cm	0.04 cm (3)	no change
Distance, Primary Vertex to Vertex Room Floor	251.5 $\pm$ 10 cm	no change	no change
Feed Pattern taper at edge of Secondary	- 11.5 dB typical	no change	-13 typical

Figure 1 – VLA Cassegrain Geometry Drawing



4.2 Requirements
The requirements in this section are traceable to the EVLA Proposal and the Supplemental Information for the NSF document. Additional requirement details are expected in the form of Science Requirements and System Engineering Requirements.

4.3 Antennas
It is not anticipated that significant modifications to the antenna structure will be required for EVLA. However, the antennas will be modified to accommodate all EVLA enhancements. The emphasis is on providing a VLBA-style feed cone and mounting the new feeds and a larger L-band horn, and altering the current feed circle layout.

4.3.1 Safety
The VLA Antennas are currently in compliance with OSHA standards for fall protection, Lock-out/Tag-out, etc. All modifications will be designed and installed so as to maintain compliance.

4.3.2 RFI
The increased use of digital devices on the antennas may make RFI containment a priority for the EVLA, particularly in the vertex room. Therefore, the feed cone will be designed as a continuous conductive enclosure. Additionally, steps will be taken to block the RF path between the feed cone and horns. Additional measures will be considered after the required level of RF containment has been specified.

RFI considerations will be closely observed during the design of the feeds, feed cone, and any waveguide components that may be required to interface the feeds to the receivers. An EVLA system level RFI plan is currently under development. Mean while the baseline design is that the feed cone will be a conductive enclosure over the vertex room. It will need to be conductively sealed to the vertex room. The shielding effectiveness as a function of frequency around the feed cone and vertex room should be used to generate emission strength requirements for the receiver and LO/IF components within each feed cone/vertex room. The emission level requirements will be sufficiently low such that a given antenna will not couple internally to its own receivers or radiate out to other antennas levels of emissions deemed harmful by the current ITU requirements for Radio Astronomy.

4.3.3 Cabling
In general, EVLA cables will follow VLA routings outside the vertex room. The waveguide will be replaced with fiber. We will need to determine early on whether a watch-spring azimuth cable wrap is required.   Inside the vertex room, cable routing as well as tube/duct/conduit routing and rack placement will be addressed a system’s engineering task.

4.3.4 Feed Cone

Figure 2 - VLA Vertex with K/Q Feed Cone Segment

Figure 3 - VLBA Feed Cone

4.3.4.1 Structure

As originally configured, VLA X, L, and Q-Band feeds are mounted in individual enclosures. K, C, and Ku share a common enclosure. The enclosures are mounted to a structure coincident with the plane of the antenna vertex - the "feed support structure". More feeds can be positioned at the Cassegrain focus if the several enclosures are consolidated. Consolidation also simplifies receiver access, RFI shielding, and temperature control. The consolidated enclosure must provide flexibility in feed size and positioning.

The VLBA antennas are constructed with a "feed cone" (Figure 3) in which all Cassegrain feeds are mounted. The VLBA feed cone is welded aluminum, strong enough to support the feeds from its roof. This concept has been adapted for the EVLA.

The first phase of the feed cone project is a pie-shaped segment housing K and Q-Band feeds. Installations began in 1997, and will be completed in 2002. Segments are constructed of aluminum/polycarbonate-laminated sheets in a welded aluminum frame (Figure 2). This construction technique offers good thermal insulation, RFI shielding, structural rigidity, and relatively simple fabrication. The pie-shaped design permits adding more segments as new feeds become available. There are no sidewalls between segments, so the finished feed cone will form a single room.

It may be desirable to continue implementing feed cones in phases, maintaining availability of existing feeds while new feeds are developed and installed. Another possibility is a one-piece feed cone. The one-piece concept offers potential cost savings and performance enhancements.

The current focus of this aspect of the project is to prototype the one-piece feed cone. Once an acceptable prototype is built, we can compare the segmented and monolithic designs and decide which to use.

4.3.4.2 HVAC
The 20-year-old vertex house HVAC systems will be replaced with new, more efficient units, sized for the increased load of the EVLA. (The DDC controls will be retained.) Specifications for this system will be refined during the PDR. No changes are required to the HVAC system supplying the pedestal room.

Preliminary Vertex Room/Feed Cone HVAC Specifications	
Supply Air Temperature	18 ± 1º C
Max ΔT between supply and return air	3º C
Equipment heat load	2 kW
Humidity control	Not required

4.3.4.3 Electrical Service
If necessary, the electrical service will be upgraded to accommodate the additional load. Anticipated additional loads include new receivers and feed de-icers.

Each antenna should have two powers sources:

1. a "clean-power" source for sensitive electronic equipment, and
2. a "dirty-power" source for noisy and high surge current equipment

The clean and dirty power sources are typically separated at the antenna using a high-isolation transformer. Equipment that should be on dirty power includes fans, motors, pumps, feed heaters, and HVAC units.

A crude estimate suggests that no increased service will be required in the vertex room for EVLA electronic equipment. The service to the vertex room for electronic equipment is currently 120 VAC @70A while the power supplies for the electronic are capable of sinking less than 30A AC combined. There are no indications at this point that the EVLA vertex room electronics will require a service close to 70 A. Detailed estimated power budget is planned.

4.3.5 Antenna Structural Modifications
The EVLA L-Band horn is so big that structural modifications of the antenna may be necessary to fit it in.
The objective for this aspect of the project is to perform the necessary modifications without degrading antenna performance. To that end, an accurate Finite Element model of the antenna has been developed. The effects of all changes will be predicted using the model before implementation. Holographic studies will be performed before and after modification of the first antenna to verify the FEM predictions. Additional antennas will be modified only after insuring that the modifications do not impair performance.

4.3.6 Pointing Improvements
The objective of this aspect of the project is to bring all antennas to a blind pointing accuracy of six arcsec and a referenced pointing accuracy of two arcsec. Although specified by EVLA, pointing improvements are currently not included in the scope of EVLA Phase I. Efforts to meet of exceed the EVLA pointing requirements include: replacement of three azimuth bearings, encoder upgrades, and diagnostics using optical telescopes.

Encoder upgrades are currently being performed under a separate project started in 1999 and funded through the regular ES Operational budget. Since the current VLA servo system electronics have become old and unreliable, this ES Operational project was established to improve the reliability, configurability, and performance of the servo system. Although the current VLA servo system will not interface directly with the EVLA system, the new servo system will be compatible with both the original VLA and EVLA. This ES Operational project has three parts: encoder system, servo loop, and Antenna Control Unit (ACU). The encoder system is designed and is currently being installed on VLA antennas. The servo loop and ACU, which are not expected to have any significant impact on pointing improvements, are scheduled to be completed and ready for installation before EVLA Phase I Antenna outfitting begins in April 2003.

4.4 Feeds and Optics

4.4.1 Overview

It is proposed that the 1-50 GHz continuous frequency coverage requirement will be obtained by sub-dividing the 50 GHz range into discrete bands. The factors considered when selecting the bandwidths for each band include: (1) available technology, (2) the number of receivers/feeds, and (3) performance of the receiver/feed/antenna at the band edges. [(4)] The number of bands proposed is eight. These bands are identified in Table 2 along with the proposed bandwidth per band. For comparison, Table 2 also includes the operational frequency range of the VLA where appropriate.

Table 2 - Frequency Coverage and Bandwidth

Band Designation	EVLA Frequency Range (GHz)	EVLA Bandwidth Ratio	VLA Operational Frequency Range (GHz)	VLA Operational Bandwidth Ratio
L	1.0 – 2.0	2.0	1.150-1.750	1.52
S	2.0 – 4.0	2.0	None Available	N/A
C	4.0 – 8.0	2.0	4.200-5.100	1.21
X	8.0 – 12.0	1.5	6.800-9.600	1.41
U	12.0 – 18.0	1.5	13.50-16.30	1.21
K	18.0 – 26.5	1.5	20.80-25.80	1.24
Ka	26.5 – 40.0	1.5	None Available	N/A
Q	40.0 – 50.0	1.25	38.00-51.00	1.34

The frequency range defined in Table 2 for each band may vary by a few percent depending on the availability of some commercial components that will be used. The existing VLA K and Q band receivers and feeds will be used for EVLA. Notice that Table-2 indicates that the existing K-band system does not meet the operation frequency range for EVLA. The existing K-band receivers and feeds were designed and are tested for operation over the entire 18.0 to 26.5 GHz range. It is the tunable range of the existing VLA LO/IF subsystem that limits current performance. To interface with the new EVLA LO/IF subsystem, the existing K-band receivers will require a minor modification to change its IF output from C-band to X-band. Furthermore, notice that the existing Q-band receiver and feeds system provides an operation bandwidth that exceeds the EVLA requirement. New S and Ka band receivers and feeds will be designed and manufactured to meet EVLA requirements. The remaining bands, (L, C, X, and U) will require substantial receiver modifications and new feed designs.

The principal performance requirements for each band are provided in Table-3. A system temperature budgets (TBD, per band) will allocate noise temperature requirements to various antenna and receiver components. The noise temperature requirements allocated to feeds, and wave-guide components will define the insertion loss and return loss specifications for these components. Likewise, a system efficiency budget (TBD, per band) will define the taper of the feed pattern at the edge of the subreflector, side lobe levels, and return loss of the feed

Table 3 - Principal Performance Requirements by Band

Band Designation	Frequency Range (GHz)	Bandwidth Ratio	System Temperature (K)	Total System Efficiency
L	1.0 – 2.0	2.0	26	0.50
S	2.0 – 4.0	2.0	29	0.62
C	4.0 – 8.0	2.0	31	0.60
X	8.0 – 12.0	1.5	34	0.56
U	12.0 – 18.0	1.5	39	0.54
K	18.0 – 26.5	1.5	54	0.51
Ka	26.5 – 40.0	1.5	45	0.39
Q	40.0 – 50.0	1.25	66*	0.34

* At low frequency end of the band

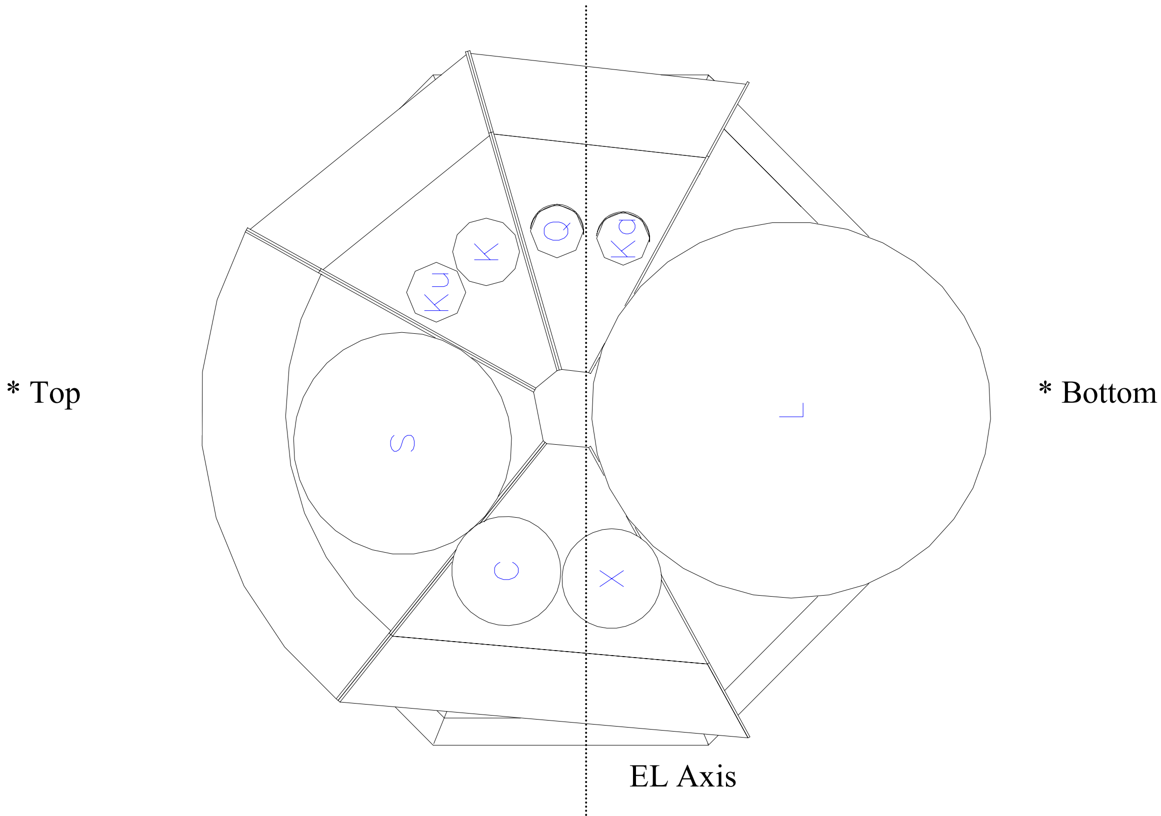
4.4.2 Polarization
All feeds will provide dual circular polarization, and they will be designed to minimize imbalances that reduce cross-polarization isolation.

4.4.3 Polarization Purity
Polarization purity will be less than 5% for each of the eight bands except at the band edges. This requirement will be used to specify the ellipticity/axial ratio, and cross-polarization isolation.

4.4.4 Feed Circle Layout
The feed system layout will take into account the effects of gravitational sag and mechanical stresses that could cause misalignment between feeds and the secondary reflector, which is most critical at shorter wavelengths. Design considerations will include the flexibility for future frequency coverage below 1 GHz to 300 MHz or lower. Dichroic operational capabilities will also be taken into consideration when choosing the final feed ring layout. Finally, future expansion to 86 GHz will also be considered.

The current feed circle layout is shown in figure 4. This plan uses the sectional wedges as described in paragraph 4.3.4.1 above.

Figure 4 – EVLA Feed Layout & Transition Plan (10/01/01)



* Top and Bottom are referenced to an observer looking into the antenna at horizon pointing (0 degrees EL)

This design assumes that any Water Vapor Radiometer (WVR) on an antenna will use the K-Band feed and receiver as it's input, and that this WVR will be making continuous measurements of atmospheric disturbances even though astronomical observations are being made in other bands. To minimize residual phase errors due to beam divergence between the astronomical beam and the WVR beam, the K-Band feed will be located as close as possible to feeds of even shorter wavelength. [(5)]

The transition plan has been considered with this design of the feed circle. The base-line plan is that the 1st time an antenna comes into the barn for EVLA modification, it will receive a complete new feed cone (either the hollow segmented design or the single piece cone design). A new L-band feed will be installed (with old L-band Rx if necessary, which would mean fabrication of a bit of waveguide transition) and all existing feeds and receivers will be moved to their assigned positions in the new feed cone design. This design approach may have a cause a small loss in performance for Ku and C band receivers during a period of up to six months or more. This loss of performance is in terms of a system temperature increase due to temporary waveguide used to connect the C and Ku band receivers to the existing "A" rack until replacement receivers are available. The project's scientists are evaluating this issue to determine if the losses are acceptable.

Design flexibility to facilitate future capabilities have also been evaluated in terms of the current design. With the layout as shown in Figure 4, the X-C band and C-S band dichroic combinations are precluded. The scientists are evaluating this loss of flexibility and what other combinations could be useful. To facilitate the possible future addition of a 3 mm receiver, various possible scenarios for integrating the 3mm receiver were entertained and evaluated at a high level. Since there was no obvious reason that the current feed circle layout would preclude implementing any of these scenarios, we feel that the current design sufficiently addresses the future addition of a 3mm receive. For reference the scenarios considered are listed below.

1. Add the 3mm receiver near the centroid of the upper right quadrant in the space there, and then add a pick-off mirror above the Q-band feed.
2. Put the 3mm receiver in the same dewar as Q-band, and have both look through the same hole in the enclosure. This may be difficult since it would involve a retrofit to the current Q-band systems, but it is a possibility.
3. Direct the beam with reflectors for both Q and W-band frequencies through the feed cone and split using a flip reflector to the appropriate receiver.
4. Utilize freed space on feed circle by the reduced size of L-Band feed.

4.4.5 Feed/Receiver Windows and Radomes

Some VLA feeds have as many as three dielectric windows or radomes before the receiver. Increased bandwidth in the EVLA feeds along with moisture reduction techniques will put increased mechanical and electrical performance requirements on the EVLA window and Radome specifications. Although the receiver vacuum pressure window is part of the receiver, it will be addressed here with feed window and Radome to insure that all dielectric boundaries are considered when evaluating materials and designs.

4.4.6 Feed System Moisture and Corrosion Protection

The feed system will be protected from moisture that can cause signal degradation. Moisture and atmospheric contaminants that can cause corrosion in the feeds will also be minimized. The first line of defense will include sealing all feed apertures and sectional joints. A dry air or nitrogen pressurization system will be considered.

Feed heater have proven to be valuable in reducing ice on feed and drying condensation of feed radomes at both the VLA and VLBA; therefore, these heaters will be used on EVLA as well. However, it will be recommended that they be powered from a "dirty power" source.

4.5 Feed System Specifications

This section contains specifications for the EVLA feeds. These specifications are traceable to one or more requirements listed in section 4.4. All polarizer components for the EVLA will be inside the receiver dewar and cooled to 15 K. Because they are physically located in the dewar, their specifications are provide in Chapter 5 of the EVLA Project Book, which is the chapter for Front Ends. Attempts will be made to interface the feeds directly to the receivers to minimize loss, assembly length, and costs. Therefore, in the following specifications it is assumed that no waveguide transitions will be required.

4.5.1 General Specifications for Feeds

General specifications are those that pertain to all feeds. As the design and development process proceeds general specifications may be tailored for specific feeds.

(a) The optics and feed system will provide outputs for the following bands:
- 1.0-2.0 GHz
- 2.0-4.0 GHz
- 4.0-8.0 GHz
- 8.0-12.0 GHz

- 12.0-18.0 GHz
- 18.0-26.5 GHz
- 26.5-40.0 GHz
- 40.0-50.0 GHz

(b) All feeds will provide on-axis cross-polarization isolation better than -30 dB across the band.
(c) All feeds will provide off-axis cross-polarization isolation greater than xx dB (TBD) across the band regardless of the off-axis angle
(d) All feeds will be optimized to provide the maximum possible on-axis G/T_{sys} performance across the band.
(e) Environmental
- Operational Temperature Range (-30 C to +45 C)
- UV protection – TBD
- Humidity – TBD
- Feeds will be covered to protect against moisture and creatures
- Feed heater will be used to keep ice from forming on the feed covers

(f) (this item intentionally left blank)

4.5.2 L-Band Feed (1.0-2.0 GHz)

The VLA frequency coverage for L-Band is from 1.150 to 1.750 GHz. Full band operation requires a feed substantially larger in both length and aperture than the current VLA L-Band horn. The new wide-band design must fit into the limited space of the feed circle, while properly illuminating the VLA sub-reflector. Alternatively, a smaller horn may be possible using new dielectric materials to fabricate a microwave lens.

Table 4 – L-Band Feed Specifications

Item	Nomenclature
Type	Compact Corrugated (bell shape)
Frequency Range	1.0 –2.0 GHz
Polarization	Dual circular
Return Loss	< -25.0 dB
Cross-polarization Isolation (on-axis)	< -30.0 dB
Cross-polarization Isolation (off-axis)	>xx dB @ x deg off-axis TBD
Taper (1.5 GHz)	- 12.0 +/- 0.5 dB
Taper (1.0 and 2.0 GHz)	-12.0 +/- 2.0 dB
First Side Lobe Level (max)	< -30.0 dB (rel. to main lobe)
Distance from Phase Center to Aperture (1.2, 1.6, 2.0 GHz)	Xxx inches TBD
Length (max)	170 in.
Aperture Diameter (max)	65 in.
Weight (max)	600 lbs.

4.5.3 S-Band Feed (2.0-4.0 GHz)

The VLA provides no frequency coverage for S-Band. The new wide-band design must fit into the limited space of the feed circle, while properly illuminating the VLA sub-reflector.

Table 5 – S-Band Feed Specifications

Item	Nomenclature
Type	Compact Corrugated (bell shape)
Frequency Range	2.0 –4.0 GHz
Polarization	Dual circular
Return Loss	< -25.0 dB
Cross-polarization Isolation (on-axis)	< -30.0 dB
Cross-polarization Isolation (off-axis)	>xx dB @ x deg off-axis TBD
Taper (3.0 GHz)	-13.0 +/- 0.5 dB
Taper (2.0 and 4.0 GHz)	-13.0 +/- 1.0 dB
First Side Lobe Level (max)	< -30.0 dB (rel. to main lobe)
Distance from Phase Center to Aperture (max)??	x in.
Length (max)	150 in.
Aperture Diameter (max)	50 in.
Weight (max)	400 lbs.

4.5.4 C-Band Feed (4.0-8.0 GHz)

The VLA frequency coverage for C-Band is from 4.200 to 5.100 GHz . The new wide-band design must fit into the limited space of the feed circle, while properly illuminating the VLA sub-reflector.

Table 6 – C-Band Feed Specifications

Item	Nomenclature
Type	Compact Corrugated (bell shape)
Frequency Range	4.0 –8.0 GHz
Polarization	Dual circular
Return Loss	< -25.0 dB
Cross-polarization Isolation (on-axis)	< -30.0 dB
Cross-polarization Isolation (off-axis)	>xx dB @ x deg off-axis TBD
Taper (6.0 GHz)	-13.0 +/- 0.5 dB
Taper (4.0 and 8.0 GHz)	-13.0 +/- 1.0 dB
First Side Lobe Level (max)	< -30 dB (rel. to main lobe)
Distance from Phase Center to Aperture (max)??	Xxx in. TBD
Length (max)	75 in.
Aperture Diameter (max)	30 in.
Weight (max)	250 lbs.

4.5.5 X-Band Feed (8.0-12.0 GHz)

The VLA frequency coverage for X-Band is from 6.800 to 9.600 GHz. The new wide-band design must fit into the limited space of the feed circle, while properly illuminating the VLA sub-reflector.

Table 7 – X-Band Feed Specifications

Item	Nomenclature
Type	Linear Taper Corrugated
Frequency Range	8.0 –12.0 GHz
Polarization	Dual circular
Return Loss	< -25.0 dB
Cross-polarization Isolation (on-axis)	< -30.0 dB
Cross-polarization Isolation (off-axis)	>xx dB @ x deg off-axis TBD
Taper (10.0 GHz)	-13.0 +/- 0.5 dB
Taper (8.0 and 12.0 GHz)	-13.0 +/- 1.0 dB
First Side Lobe Level (max)	< -30.0 dB (rel. to main lobe)
Distance from Phase Center to Aperture (max)??	Xxx in. TBD
Length (max)	50 in.
Aperture Diameter (max)	22 in.
Weight (max)	Xx lbs. TBD

4.5.6 Ku-Band Feed (12.0-18.0 GHz)

The VLA frequency coverage for Ku-Band is from 13.500 to 16.300 GHz. The new wide-band design must fit into the limited space of the feed circle, while properly illuminating the VLA sub-reflector.

Table 8 – Ku-Band Feed Specifications

Item	Nomenclature
Type	Linear Taper Corrugated
Frequency Range	12.0 –18.0 GHz
Polarization	Dual circular
Return Loss	< -25.0 dB
Cross-polarization Isolation (on-axis)	< -30.0 dB
Cross-polarization Isolation (off-axis)	>xx dB @ x deg off-axis TBD
Taper (15.0 GHz)	–13.0 +/- 0.5 dB
Taper (12.0 and 18.0 GHz)	–13.0 +/- 1.0 dB
First Side Lobe Level (max)	< -30.0 dB (rel. to main lobe)
Distance from Phase Center to Aperture (max)??	Xxx in. TBD
Length (max)	35 in.
Aperture Diameter (max)	15 in.
Weight (max)	Xx lbs. TBD

4.5.7 K-Band Feed (18.0-26.5 GHz)

The VLA frequency coverage for K-Band is from 20.8 – 25.8 GHz. The existing wide-band feed and receiver must fit into the limited space of the feed circle, while properly illuminating the VLA sub-reflector. The existing feed and receiver are limited in frequency operation by the LO/IF system in the VLA. Full band functionality will be possible with the EVLA LO/IF system.

Table 9 – K-Band Feed Specifications

Item	Nomenclature
Type	Linear Taper Corrugated
Frequency Range	18.0 –26.5 GHz
Polarization	Dual circular
Return Loss	< -25.0 dB
Cross-polarization Isolation (on-axis)	< -30.0 dB
Cross-polarization Isolation (off-axis)	>xx dB @ x deg off-axis TBD
Taper (22.25 GHz)	-13.0+/- 0.5 dB
Taper (18.0 and 26.5 GHz)	-13.0 +/- 0.5 dB
First Side Lobe Level (max)	< -30.0 dB (rel. to main lobe)
Distance from Phase Center to Aperture (max)??	Xxx in. TBD
Length (max)	22 in.
Aperture Diameter (max)	10 in.
Weight (max)	Xx lbs. TBD

4.5.8 Ka-Band Feed (26.5-40.0 GHz)

The VLA provides no frequency coverage for Ka-Band. The new wide-band design must fit into the limited space of the feed circle, while properly illuminating the VLA sub-reflector.

Table 10 – Ka-Band Feed Specifications

Item	Nomenclature
Type	Linear Taper Corrugated
Frequency Range	26.5 –40.0 GHz
Polarization	Dual circular
Return Loss	< -25.0 dB
Cross-polarization Isolation (on-axis)	< -30.0 dB
Cross-polarization Isolation (off-axis)	>xx dB @ x deg off-axis TBD
Taper (33.25 GHz)	-13.0 +/- 0.5 dB TBD
Taper (26.5 and 40.0 GHz)	-13.0Xx +/- 1.0 dB TBD
First Side Lobe Level (max)	< -30.0 dB (rel. to main lobe)
Distance from Phase Center to Aperture (max)??	Xxx in. TBD
Length (max)	15 in. TBD
Aperture Diameter (max)	6 in. TBD
Weight (max)	Xx lbs. TBD

4.5.9 Q-Band Feed (40.0-50.0 GHz)

The VLA frequency coverage for Q-Band is from 38.0 to 51.0 GHz. This existing wide-band feed and receiver must fit into the limited space of the feed circle, while properly illuminating the VLA sub-reflector.

Table 11 – Q-Band Feed Specifications

Item	Nomenclature
Type	Linear Taper Corrugated
Frequency Range	40.0 –50.0 GHz
Polarization	Dual circular
Return Loss	<- 25.0 dB
Cross-polarization Isolation (on-axis)	< -30.0 dB
Cross-polarization Isolation (off-axis)	>xx dB @ x deg off-axis TBD
Taper (45.0 GHz)	–13.0 +/- 0.5 dB
Taper (40.0 and 50.0 GHz)	–13.0 +/- 1.0 dB
First Side Lobe Level (max)	< -30.0 dB (rel. to main lobe)
Distance from Phase Center to Aperture (max)??	Xxx in. TBD
Length (max)	10 in. TBD
Aperture Diameter (max)	4 in. TBD
Weight (max)	Xx lbs. TBD

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