Radio Interference at the VLA Site

VLA Electronics Memorandum No. 205

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L-Band

VLA Tuning Range 1340-1730 MHz

VLA Default Bands:	HH	1405-1430 MHz
	HH	1405-1417.5 MHz
	LL	1440-1490 MHz

Of the four VLA bands, L-band is the one in which interference is most likely to be encountered. Table I shows a simplified listing of the frequency allocations within the VLA tuning ranges. Note that there are only two L-band assignments to radio astronomy, 1400-1427 MHz, primary and shared with passive services*, and 1660-1670 MHz, primary but shared with meteorological aids (mainly radiosonde balloons). The numbers of unclassified government assignments in the area, including White Sands Missile Range, provide some idea of the frequency usage. However, they do not include classified assignments and, in the range 1429-1660.5 MHz, there are also non-government assignments. Much of the equipment at White Sands is used only sporadically. Usage can be heavy during special training missions which typically occur for one or two weeks of each year. Only the 1400-1427 MHz band can be depended upon to be free from intentional transmissions. The following signals should be noted:

*Passive services do not transmit, and include mainly the use of radiometers in space research and the earth-exploration satellite programs.

West Mesa Radar FAA radar in Albuquerque. Nominal frequencies 1310 and 1330 MHz, but can be tuned within the 1300-1350 MHz band. Produces a strong signal at the VLA site.

Navstar VII This satellite, to be launched in late 1982, will carry a nuclear - burst detector which transmits data to Vandenberg AFB at a frequency of 1381 MHz. Sidebands extend for several tens of megahertz on the low-frequency side, but on the high side are out cut off above 1400 MHz by a special filter. Fortunately these transmissions are expected to be of 1-2 minutes duration only, and occur about twice each day.

1404 MHz Because of a spurious response in the upconverters, a Forest Service communications signal (South Baldy to Magdalena ranger station) at 1796 MHz appears as an interfering signal at 1404 MHz. The signal is present at all times and users are advised to avoid making observation with this frequency within the receiving band. The spurious response will be eliminated when the L-band front ends are modified to use cooled FET amplifiers.

1405-1427 MHz This part of the radio astronomy band was believed to be free of interfering signals until interference was experienced during an observation in Nov. 1981. Investigation using the spectral correlator has shown a signal at 1410 MHz, no wider than one 24 kHz channel, and probably not strong enough to interfere with continuum observations in 12.5 MHz bandwidth. Investigation of signals in the band is continuing.

Navstar Satellites All satellites of the Navstar series, of which it is planned eventually to use 24 in orbit simultaneously, radiate a spectrum centered on 1575 MHz and capable of causing interference to the VLA over a band about 100 MHz wide. However, since these satellites traverse the sky at about twice the sideral rate, and with the opposite sense of

rotation, the fringe frequency discrimination inherent in the VLA should greatly reduce the response to their transmissions.

Meteorological Balloons The National Weather Service makes soundings up to 100,000 ft. using radiosonde balloons from Albuquerque, El Paso, Amarillo, and Tucson. These flights have durations of about one hour centered on 0^h and 12^h U.T., and use transmitters in the range 1660-1700 MHz. The U. S. Air Force uses similar equipment from various bases including White Sands, but operates at any times that data are required. During June through September each year radiosondes are flown for research programs from Langmuir Laboratory, 40 km east of the VLA site. Dr. Charles Moore of NMIMT has promised to tune the transmitters as high in the band as possible to avoid the OH lines, but equipment brought in by visiting scientists to Langmuir may not be capable of such tuning. Radiosondes are used from Langmuir during daylight hours only.

Meteorological Satellites The band 1670-1710 MHz is also allocated to space-to-earth transmissions by both geostationary and non-geostationary meteorological satellites.

1714 MHz from North Oscura Peak This is a communications signal in the White Sands network and it can cause interference because North Oscura peak is close to line-of-sight from the VLA. Allow at least 0.5 MHz clearance from 1714 MHz.

1710-1850 MHz Usage of the band 1710-1850 MHz, which is assigned to government fixed and mobile communications, is increasing. Through coordination with government agencies we are attempting to keep the 1720 MHz OH-line frequency clear in the vicinity of the VLA. Because of a spurious response in the L-band upconverters in the VLA, a signal at frequency f can cause interference to observations at a frequency 3200

MHz minus f. Thus signals in the range 1710 - 1850 MHz could appear as interference between 1350 and 1490 MHz.

The unwanted response is 20 to 30 dB down relative to the standard upconverter response. It is planned to eliminate this problem by replacing the upconverters with FET amplifiers within a few years following 1982.

Self-generated Interference at L-Band Harmonics of 50 MHz are generated in the local oscillator system at each antenna, and some of these are picked up at very low levels in the receiving system. Their strength varies from one antenna to another but is generally below the level which causes harmful interference to continuum observations with bandwidths of 6.25 MHz and greater. However in spectral line mode they will be detected at 1350, 1400, 1450 MHz etc.

General Conclusion For 50 MHz bandwidth good experience has usually been obtained using a center frequency of 1485 MHz. Near the high end of the 1340-1730 MHz band sporadic interference is likely to be experienced when using a 50 MHz bandwidth, and a center frequency of 1665 MHz has been found to be about as good as any.

C-Band

VLA Tuning Range 4500-5000 MHz

VLA Default Band: CC 4860-4910 MHz

As Table I shows, only 10 MHz of this band is allocated to radio astronomy and passive services on an exclusive basis. Internationally, the WARC of 1979 extended the radio astronomy allocation down to 4800 MHz on a secondary basis, but this is unlikely to be implemented within the U.S. Experience shows that very little interference is encountered in the top 150 MHz of the band where most VLA observations have been

made. Frequency monitoring by G. Bonebrake in 1976 revealed only a weak sporadic signal at 4700 MHz.

Self Generated Interference Only one self-generated signal is known at C-band, at 4800 MHz, which is the second harmonic of a signal generated to provide a reference for the modem oscillators.

U - Band

VLA Tuning Range 14.4-15.4 GHz

VLA Default Band: UU 14.94 - 14.99 GHz

The band 15.35 to 15.4 GHz is allocated exclusively to radio astronomy and passive services, and at the 1979 W.A.R.C. radio astronomy was given an international secondary allocation in the band 14.47-14.5 GHz, to protect the Formaldehyde line. Very little interference has been experienced at the VLA site in the 14.4-15.4 MHz band.

Self Generated Interference at U-Band There are three known mechanisms by which self-generated interference appears in this band. The apparent sky frequencies are as follows:

(a) Harmonics of 600 MHz

(b) F3 frequency minus 4.8 GHz. This results from the 4.8 GHz signal picked up in the parametric amplifiers.

(c) (14.54 ± 0.04) GHz (For F3 frequency = 19 GHz only).

(14.34 ± 0.04) GHz (For F3 frequency = 19.1 GHz only).

These signals occur when 2 x (paramp pump frequency) minus 2 x (F3 frequency) falls within the input signal band. The paramp pump frequency is 26.27 ± 0.02 GHz. Since the pumps are not synchronized, the interference should not be strong but may cause errors in the data.

K - Band

VLA Tuning Range 22-24 GHz

VLA Default Band: KK 22.46-22.51 GHz

The band 22.21 - 22.5 GHz* is allocated to radio astronomy on a primary basis shared with the fixed and mobile communications services (except aeronautical-mobile), and the band 23.6-24 GHz is allocated exclusively to radio astronomy and passive services. There is very little evidence of any interference in the 22 - 24 GHz band, except for a weak signal at 22.684 GHz recorded on one occasion during a spectral line observation.

Self-Generated Interference at K-Band The same mechanisms that cause interference at U Band occur also at K - band. These occur at the following sky frequencies:

(a) Harmonics of 600 MHz

(b) F3 frequency + 4.8 Ghz. This results from the 4.8 GHz signal picked up in the parametric amplifiers.

(c) 23.46 ± 0.04 GHz (For F3 frequency = 19.0 GHz only)

23.86 ± 0.04 GHz (For F3 frequency = 19.1 GHz only)

These signals occur when 4 x (F3 frequency) minus 2 x (paramp pump frequency) falls within the input signal band. The paramp pump frequency is 26.27 ± 0.02 GHz. Since the pumps are not synchronized the interference should not be strong, but may cause errors in the data.

* Result of 1979 WARC not yet official within the U.S.

Antenna Sidelobes

A plot of approximate sidelobe levels which can be used in interference calculations is shown in Fig. 1. This curve applies to all four frequency bands and is based on the expected behavior of large reflector antennas plus various measurements on VLA antennas. The far sidelobes contain angular structure which can be as narrow as the main beam, and the curve is intended to represent the maximum level of most of the sidelobes. The effective collecting area is equal to $G\lambda^2/4\pi$ where G is the gain (power ratio corresponding to decibel level in Fig. 1) and λ is the wavelength.

TABLE I SIMPLIFIED LISTING OF U. S. FREQUENCY ALLOCATIONS WITHIN VLA BANDS

VLA BAND	ALLOCATION BAND	ALLOCATED SERVICE[1]	NO. OF UNCLASSIFIED GOVT. ASSIGNMENTS WITHIN VICINITY OF THE VLA SITE[2]
1340 - 1730 MHz	1300 - 1350 MHz	AERONAUTICAL RADIONAVIGATION	9
" " "	1350 - 1400 MHz	RADIOLOCATION, fixed, mobile	4
" " "	1400 - 1427 MHz	RADIO ASTRONOMY, PASSIVE SERVICES	0
" " "	1427 - 1530 MHz	FIXED, MOBILE	99
" " "	1530 - 1660 MHz	MOBILE SATELLITE, AERO. RADIONAV.	10
" " "	1660 - 1670 MHz	RADIO ASTRONOMY, MET. AIDS	0
" " "	1670 - 1710 MHz	METEOROLOGICAL AIDS, MET. SAT., FIXED	7
" " "	1710 - 1850 MHz	FIXED, MOBILE	102
4500 - 5000 MHz	4400 - 4990 MHz	FIXED, MOBILE, FIXED SAT.	43
" " "	4990 - 5000 MHz	RADIO ASTRONOMY, passive services	0
14.4 - 15.4 GHz	14.3 - 14.5 GHz	FIXED SAT., FIXED, MOBILE	3
" " "	14.5 - 15.35 GHz	FIXED, MOBILE	25
" " "	15.35 - 15.4 GHz	RADIO ASTRONOMY, PASSIVE SERVICES	0
22.0 - 24.0 GHz	22.0 - 22.21 GHz	FIXED, MOBILE	1
" " "	22.21 - 22.50 GHz	RADIO ASTRONOMY, FIXED, MOBILE, PASSIVE SERVICES	
" " "	22.50 - 23.60 GHz	FIXED, MOBILE, INTERSATELLITE, BROADCAST SATELLITE	
" " "	23.6 - 24.0 GHz	RADIO ASTRONOMY, PASSIVE SERVICES	0

1 Upper case letters indicate a primary allocation, lower case a secondary allocation.

2 Assignments are taken from a listing which includes all unclassified government allocations within the area between longitudes 106°W and 109°W and between latitudes 32° 30'N and 35° 30'N. For transmitter powers exceeding 100 W the area is extended to that between 105° and 110°W and 32° and 36°N. Numbers given apply to listed allocation bands.

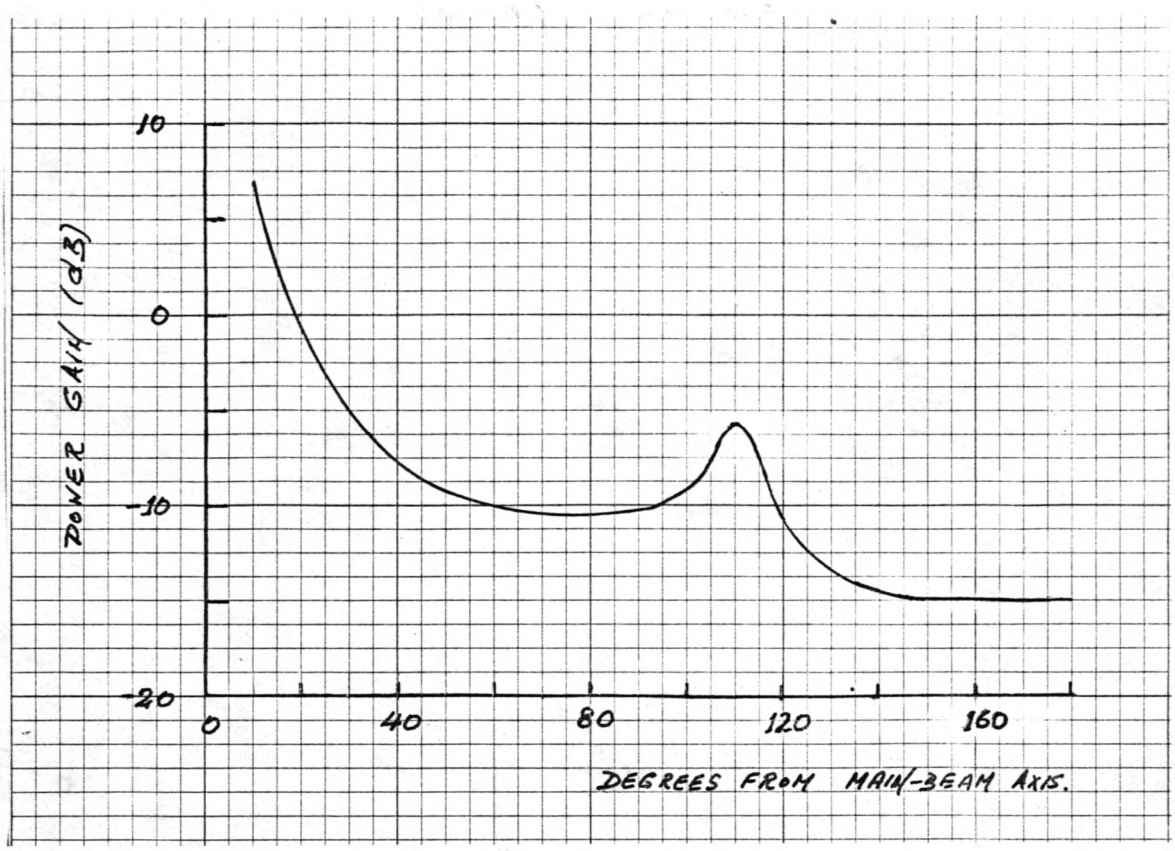

Fig. 1 Approximate estimate of sidelobe levels for VLA antennas.