NATIONAL RADIO ASTRONOMY OBSERVATORY
Post Office Box 767
Socorro, New Mexico 87801

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INTERMODULATION PRODUCTS AT L BAND

J. Dolan

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In conjunction with site RFI measurements I have investigated spurious responses in the passband of the 1300-1700 MHz radiometers. On April 20 the local oscillators were set to 15 different frequencies at steps of 20 and 30 MHz. Spurious signals as large as 40 dB above the noise could be observed in the passbands, giving signal-to-noise ratios from about 13 dB to -21 dB. These large apparently monochromatic signals moved in frequency increments by the same amount the L.O. was changed, indicating a first order mixer product. There were other small signals usually separated by 25 or 50 MHz. These observations were made on the spectrum analyzer in the Control Building equipment room.

A Hewlett Packard Model 8555A Spectrum Analyzer was carried to Antenna No. 3 vertex room and was used in the following tests.

1) At the RF splitter test point, channel A.B., a complete spectrum scan was run. The following signals were present.

FREQUENCY (MHz)	AMPLITUDE dBm (approx)
110	-30
130	-30
210	-30
240	-30
270	-30
300	-20
320	-30
350	-20
750	-30

FREQUENCY (MHz)	AMPLITUDE dBm (approx.)
900	-30
1000	-50
1175	-60
1200	-60
1225	-60
1500	-50
4600	-40
4850	-40
5000	-35
4250	
4400	-30
4450	-40

In addition to the above spurious signals, there is a comb present on both ends of the band (4-5 GHz) separated by about 25 MHz at about -50 dBm. This comb appears to be a parasitic oscillation probably in the upconverter. It is sensitive to upconverter pump power and input impedance. This is a problem that should be looked into in the laboratory, independent of the intermodulation problems.

A look at Channel C.D. revealed much the same signals at a smaller amplitude, and the parasitic comb was visible but at a slightly different frequency separation indicating the oscillations are probably due to the same mechanism, differing slightly in distributed circuit values.

Next an observation of signals present in the vertex room was made using a short piece of wire for an antenna on the anlyzer. The following signals were observed. No attempt was made to measure amplitude because of the makeshift antenna.

FREQUENCY (MHz)

5 MHz comb up to about 250 or 300 MHz
600 MHz C.W.
1200 MHz
1800 MHz
2400 MHz
3200 MHz
3500 MHz
3600 MHz

The L Band feed was then blocked and the analyzer was connected to the RF splitter of Channel A.B.

1) The ≈ 24 MHz comb was present from 4.28 to 4.45 GHz.

2) CW at 4.4 GHz ≈ 20 dB above noise
4.45 GHz ≈ 20 dB above noise
5.0 GHz ≈ 20 dB above noise

3) Small carrier just above noise at 4.62 GHz.

The feed was then unblocked. All the above signals were present plus the following.

FREQUENCY (GHz) (Amplitudes ≈ 5 to 10 dB above noise)	L BAND EQUIVALENT (MHz)
4.5	1300
4.6	1400
4.7	1500
4.84 (apparently true interference)	1640
4.85	1650
4.88	1680
4.9	1700
4.92	1720
5.1	1900

Some of the above signals may be external interference, but the system noise temperature is much lower with the feed open so the smaller intermodulation signals would appear. Later on the waveguide was removed and the input port terminated, but the system temperature will also be above 300K, and only the stronger signals would be measurable.

<u>L Band Channel AB terminated with room temperature load.</u>

In this mode, most of the smaller spurious signals could not be observed. However, two strong CW signals were still present, at 4400 MHz and 5000 MHz. The upconverter pump was removed and a Wiltron Signal Generator substituted. No change was noticed except the parasitic oscillations could be made to come and go by varying upconverter pump power.

The two strongest spurious signals, 4.4 and 5.0 GHz, are the sum of 3.2 GHz upconverter and the 1.2 and 1.8 GHz carriers.

An investigation into the way the 1.2 and 1.8 GHz signals (and probably others) are getting into the front end indicates the following.

1) Unshielded and unbypassed control and bias leads going into the dewar. By using copper tape and aluminum foil we were able to reduce the amplitude of the 4.4 and 5.0 GHz signals almost to the noise level. It should be noted that all RF lines on Rack B were disconnected and the ports terminated, leaving little doubt that the offending signals are radiated in the vertex room, and not conducted.

2) Some possible low level leakage into the waveguide joints.

Following these tests, crude dipole antennae were constructed for 1200 MHz and 1800 MHz. The spectrum analyzer was adjusted as follows:

BW = 300 kHz
Sweep Time = 20 ms/cm
Log Ret = -30
Det = 10 dB Log
Scan Width = 20 MHz/div
Antennae = dipoles, 1200, 1800 MHz
Transmission line ≈ 10 ft RG/223, Loss ≈ 1 dB

The antennae were used as probes to find the strongest signal points in the room. This is to the immediate rear (lower) of the L3 module.

With this test setup 1200 MHz is present at -46 dBm (2.5×10^{-6} W/M^2) accompanied by spurious signals every 50 MHz from 950 MHz to 1300 MHz. With the 1200 MHz dipole the nearest signals were of the order of -60 to -66 dBm going down to -80 at 950 MHz. (VSWR of the dipole is not known.)

The 1800 MHz signal is present in the same area at -34 dBm (1×10^{-4} W/M^2) with 50 MHz spurs from 1500 to 1900 MHz. With the 1800 MHz dipole the spurious amplitudes are from -76 to -82 dBm.

Once these signals are picked up and carried into the dewar the bandswitch and upconverter offer access to the signal path.

Conclusions

Most of the serious interference at present is in the L Band upconverter and amplifier system. No spurious signals were observed at C Band. At least 95% of the offending signals are system generated, and mixed in the upconverter and L.O. system.

Most, of not all, of the problems noted above are straightforward and predictable and respond to proper application of tried and proven engineering principles.

Recommendations

1) Shield and/or bypass all monitor, bias and control leads going into the dewar.

2) Reduce the amplitude of the signals emanating from Rack B by better RF enclosures, standard bypassing and shielding of control and power circuits and possibly RF tight rack panels.

3) Use RF gaskets at all waveguide flanges and pay close attention to waveguide installation procedures.

Dave Hudson helped with the measurements. The test dipoles are in his possession.