The 5^{th} IVS General Meeting Proceedings, 2008, p. 47–52

Equipment Failures, Chronic Station Problems, and RFI: Their Effects on Geodetic VLBI Data

Kerry Kingham, David Hall

U.S. Naval Observatory, USA

Abstract. In the course of processing routine IVS sessions, several common station problems reoccur. Missing channels, spurious signals, and radio frequency interference (RFI) all make correlation a challenge. We present some of these problems as they are seen at the correlator, point out their deleterious effects on the integrity of the observations, and suggest mitigation actions.

1. Introduction

In the last few years, there has been an increase in problems at network stations that directly affect the IVS products. Most of these problems directly affect the basic observable of group delay through the contamination of the bandwidth–synthesis observables or calibrations.

2. Missing Channels in Frequency Bandwidth Synthesis

One of the most serious problems in geodetic VLBI is channels deleted due to RFI or signal path problems. While dropping one channel is not a large problem, it is an issue when two stations have different missing channels, the delay resolution function now suffers from two lost channels and the effects can be more severe.

Fig. 1 shows the response in delay space of the the R4 S-Band frequency sequence. This sequence is typical of the frequencies used in geodetic VLBI sessions. Fig. 2 shows the result of losing the top three frequencies (1/2 the total). The increased amplitude of the sub–ambiguity side–lobes make it much more likely that the delay solution will find a sub-ambiguity. This will occur if only one of the upper two frequencies is lost. The correlator processing can be tuned to remove sub-ambiguities from the final export, but there is a practical limit on the time resolution that can be applied. In the extreme case, the baseline might have to be deleted. Note also that the delay resolution is half that of the all–channels case.

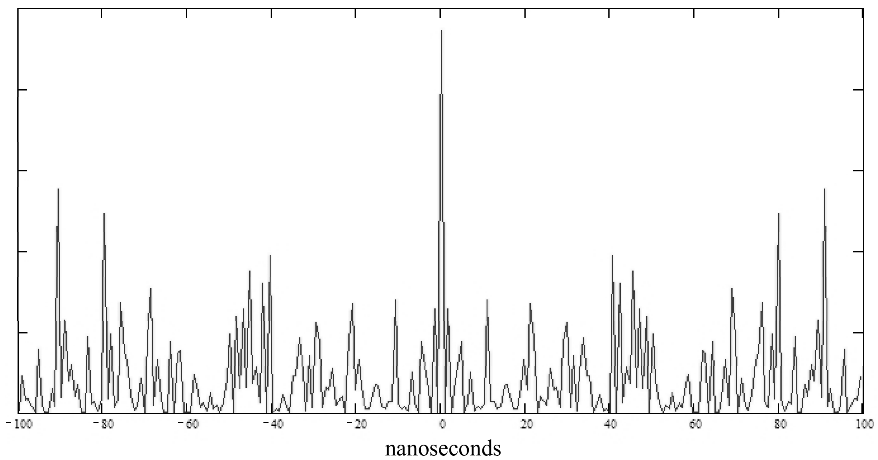

Figure 1. Delay resolution function with all S–Band channels present. The largest side–lobes at +/− 80 and +/− 90 ns are less than 60% of the main–lobe. The first ambiguity is at +/− 200 ns

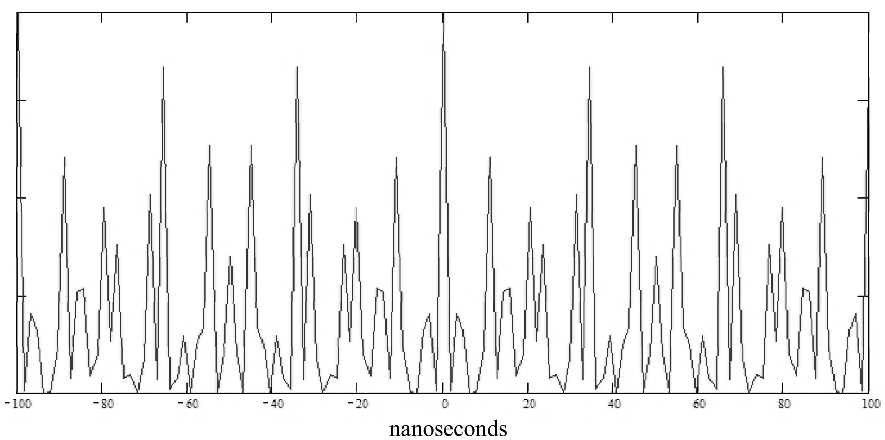

Figure 2. Delay resolution function with only the lowest 3 S–Band channels present. The first ambiguity is at +/−100 ns and the side–lobes are nearly 90% of the strength of the main–lobe

3. Spurious Signals

One of the most common problems with observations is spurious signals internal to the data acquisition rack that make it into the recorded data. It is particularly bad if these signals coincide with the phase calibration tones.

A spurious signal at a phase-cal frequency, locked to the maser (as are most of the rack–generated signals), will have a fixed phase at phase–cal extraction. The phase calibration tones will usually vary over 360° as the signal path changes over the course of an observing session. The resultant vector sum of the the two signals at different phase-cal phases is shown in Fig. 3. Note that the *amplitude* also changes with the phase–cal rotation. This results in a sine wave when the amplitude of the phase–cal signal is plotted by phase. In the left plot in Fig. 4, the case where there is no spurious signal, the amplitude is constant regardless of phase, but in the center plot of Fig. 4, there is the signature sine wave indicating a spurious tone at the phase–cal frequency. If the spurious signal is greater than −13 dB with respect to the phase cal tone, then an error in the phase cal of more than 1° of phase in that channel will result.

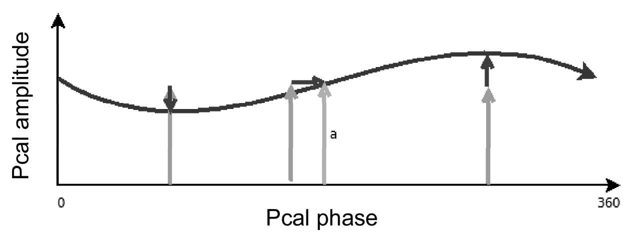

Figure 3. Vector diagram showing interaction between the phase–cal vector (big), and a spurious signal (small). Both the phase (displaced vector "a") and amplitude (sine curve) are affected

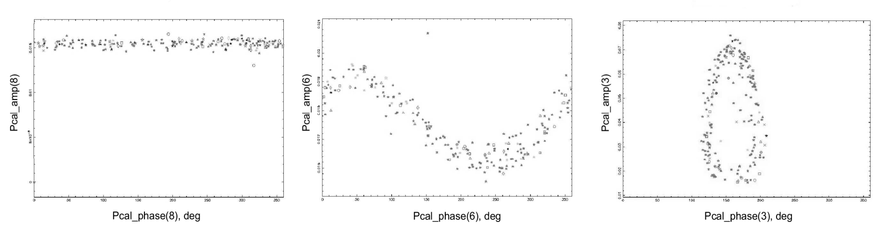

Figure 4. Three plots of amplitude versus phase for phase–cal with no spurious signals (left); a strong spurious signal (center); and a puzzling case discussed in the text (right). The center plot corresponds to the plot in Fig. 3

A rare case is shown in the right plot in Fig. 4. While initially puzzling, the diagram of Fig. 5 explains the plot. The spurious signal is stronger than the phase–cal tone, about twice the power. In this case manual phase–cal must be used.

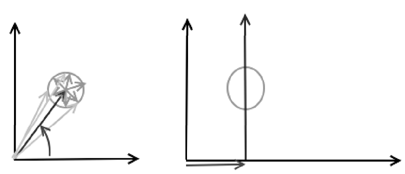

Figure 5. Vector diagram explaining the right plot in Fig. 4. In the left plot, the (dark) spurious signal, which is locked to the maser and does not rotate is stronger than the phase–cal (small and light vectors) which is rotating through 360°

4. External Radio Frequency Interference (RFI)

External Radio Frequency Interference (RFI), for our purposes, is defined as unwanted signals that are generated outside the Data Acquisition System and are not locked to the maser. These signals usually do not show up at phase cal tone frequencies. They are usually detected as low amplitude channels. This effect is shown in Fig. 6. Notice that channel "d" has a low cross–correlation amplitude and the phase has more scatter than the other channels. Low amplitude can be a diagnostic of a strong, unwanted signal in the channel. Often with external RFI, this effect can be time and/or direction dependent. Fig. 7 shows the same baseline a few minutes later. Note that the amplitude is close to average and the phase aligns with the other channels.

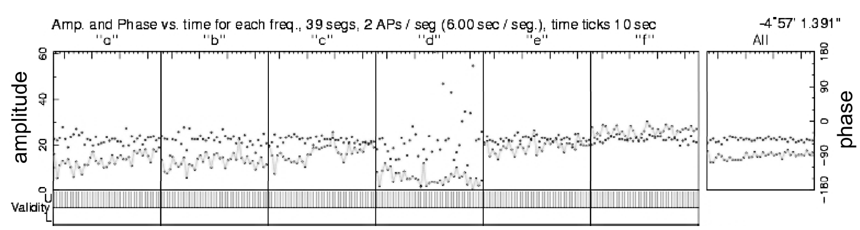

Figure 6. RFI in channel "d",which has low amplitude (line) and noisier phase (dots)

Fig. 8 shows autocorrelations of the channel bandwidth. The first plot has no RFI, the second plot is from the scan where the channel has below average amplitude and indeterminate phase. The third plot is from the second time period when the RFI did not appear serious, the interfering signal is weaker and has a different frequency.

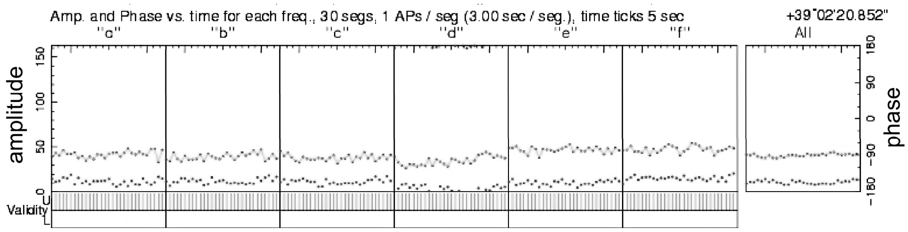

Figure 7. Same baseline and session as Fig. 6 a few minutes later. RFI is reduced

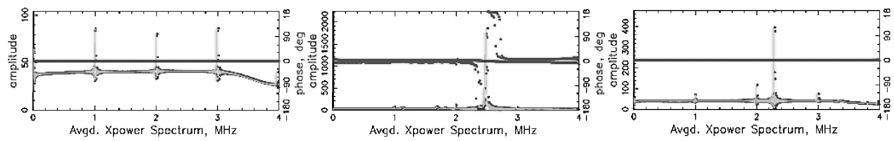

Figure 8. Three plots of Channel "d". The left plot has no RFI at all, with phase–cal tones every MHz. Middle plot is from the time period of Fig. 6, there is a signal at approximately 2.5 MHz. Right plot shows that during the time of Fig. 7 there still was a signal in the channel, but it has a lower amplitude and a shift in frequency

5. Very External RFI

The final category of interfering signal that we will consider in this paper is a very external Until recently, external sources of interference to the S-band & X-band regions used by geodetic VLBI were very rare. That situation is now changing. New services are filling the spectrum with signals. One of the worst, from the geodetic VLBI point of view, is the Direct Digital Audio Satellite service. Over North America, these services, called "XM" and "Sirius" have satellites that beam powerful S-Band signals directly at the radio telescopes. If the geodetic frequency sequence has a channel that includes a signal from these satellites, it makes the channel unusable. Examples of these signals, an out–of–passband and an in–passband example, are shown in Fig. 9. These strong, disrupting signals are also seen at Ny–Ålesund (Norway), Fortaleza (Brazil) and Kokee Park (Hawaii).

6. Discussion

None of the problems presented in this paper are new, although with the increase in recorded bandwidth over the last few years, there is more opportunity for interference to be a serious problem. There is no single solution. Stations need to be instructed in tracking down and eliminating internal spurious signals in the rack. The Technical Operations Workshops (TOW) are a good venue for this, but the station sponsors must be urged to send station

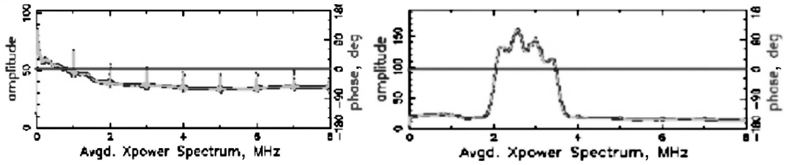

Figure 9. Autocorrelation plots of two S-Band channels. On the left, the XM signal is just off the lower edge in frequency than the passband of the channel leading to reduced phase–cal amplitudes and distorted continuum. On the right, the XM signal dominates the channel

personnel. The major external RFI sources must be mapped at each station so that rational decisions can be made concerning frequency sequences. And finally, schedulers may have to tailor frequency sequences flexibly, depending on which stations are in a session.

Acknowledgements

We would like to thank the staff of the other Mark 4 correlators for discussions about common problems, particularly Arno Müskens and Alessandra Bertarini at Bonn and Mike Titus and Brian Corey at Haystack. Brian Corey has written several memos that, put together, are a great resource in figuring out exactly what is going on with a station for a given correlator output.

The 5th IVS General Meeting Proceedings, 2008, p. 53–62

Effects on the Geodetic-VLBI Observables Due to Polarization Leakage in the Receivers

Alessandra Bertarini [1], *Walter Alef* [2], *Brian Corey* [3], *Axel Nothnagel* [1], *Craig Walker* [4]

[1]) *Institute of Geodesy and Geoinformation, Bonn University, Germany*

[2]) *Max Planck Institute for Radio Astronomy, Germany*

[3]) *MIT Haystack Observatory, USA*

[4]) *National Radio Astronomy Observatory, USA*

Abstract. Polarization leakage is one of the instrumental errors that decreases the precision of the geodetic and astrometric measurements. Its effect can be corrected in the data provided one knows the leakage characteristics. In this paper we present a project to measure the polarization leakage at some geodetic VLBI stations and at the VLBA. We describe the observation strategy used to measure the leakage, the correlation process, and some preliminary results.

1. Introduction

Polarization leakage is one of the biggest of the instrumental error sources remaining in the determination of multi-band delay (MBD) and hence in the determination of geodetic and astrometric parameters such as baseline length, Earth orientation parameters, and source positions. Leakage occurs primarily due to the electrical properties and shape of the polarizer and varies with frequency. Under certain assumptions about feed performance, Rogers [1] estimates a MBD error from polarization leakage of order 14 ps. An error term this large dominates the total error from all instrumental sources [1]. Typical MBD errors from leakage are expected to be smaller than 14 ps, and indeed the few values measured to date are typically in the range 2–9 ps at 8.4 GHz (X-band) [2]. Even at this level, the leakage error is still a major contributor, if not the dominant one, to the total instrumental error in geodetic VLBI. By solving for the intrinsic source polarization during data analysis, the rss error should further improve as reported by Rogers [1].