ELECTRICAL INTERFERENCES IN THE CASSINI COMPOSITE INFRARED SPECTROMETER.

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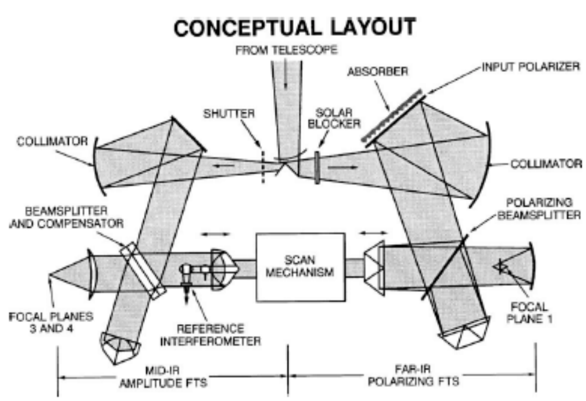
Introduction: The Composite Infrared Spectrometer (CIRS) [1] is a Fourier-Transform Spectrometer (FTS) instrument carried onboard the Cassini spacecraft in orbit around Saturn. CIRS has operated highly successfully since launch in 1997, through an encounter with Jupiter in 2000, and returned more than 100 million interferograms in the ten years since entry into orbit in 2004. However, CIRS, like many first-time instrument designs, displays an array of minor glitches, including several types of electrical interferences that cause artifacts on the spectral data. In this paper we discuss the various types of electrical noises that arise, as well as the prevention and mitigation strategies that the team has developed to eliminate or minimize the effects.

Instrument Design Overview: CIRS is a dual interferometer fed from a single 50-cm primary telescope and foreoptics (Fig. 1.) The incoming beam is split at a beamsplitter into the far-infrared interferometer (10-600 cm^{-1}) and the mid-infrared interferometer (600-1400 cm^{-1}). Both interferometers share a common scan mechanism. The far-IR interferometer signal is measured by a single bolometer detector (Focal Plane 1, or FP1), while the mid-infrared focal plane consists of two 1x10 HgCdTe detector arrays: FP3, 600-1100 cm^{-1} and FP4, 1100-1400 cm^{-1}.

Figure 1: CIRS optical layout.



Types of electrical noises displayed: CIRS displays an array of noise artifacts as follows:

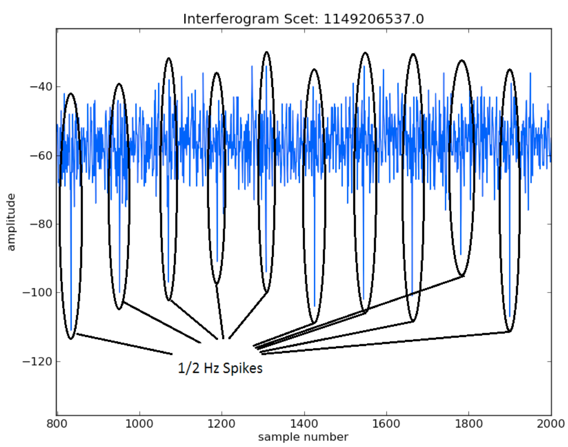
Table 1: Summary of CIRS Electrical Noises

Frequency	Description and Location	Mitigation
1/2 Hz	Science Packet Collection FP1, and FP3	Shifted 5 ms per scan and software filtering
1 Hz	Analog Multiplexer FP1, and FP3	Randomized Mux readout timing
8 Hz	Spacecraft Communications Cycle FP1, and FP3	Shifted 5 ms per scan and software filtering
8 Hz	Internal Numerical Filter FP1, FP3, and FP4	Randomized processing schedule and software filtering
8.3 Hz	Unknown Source FP3	No mitigation
2-16 Hz	Sine Wave Noise FP1, and FP3	Software filtering under development

Descriptions of the most notable of these noise interferences now follows.

Half-Hertz BIU Noise. this low-frequency noise on FP1 and FP3 is caused by the communications between the instrument and the spacecraft command and data handling system (CDS) or data bus. This occurs every two seconds when the CIRS bus interface unit (BIU) receives a query from the CDS requesting data packets. The result is a regular series of electrical spikes appearing as a comb on the interferograms (see Fig. 2). The mitigation strategy for this type of noise is to add 5 ms to the duration of each consecutive scan, which means that the spikes are 400x (2.000s/0.005s) less likely to be exactly aligned when any two randomly selected interferograms are added together. Another way to understand this is to say that the phase of the spikes displayed in the final spectra has 400 intermediate values before repeating. The overall effect is to cause the spike signal to tend to average to zero. Additionally, post-processing of the interferograms on the ground to attempt to identify and remove the spike comb.

Figure 2: section of an interferogram of deep space from the detector at FP1 in a 50 sec scan with .5 Hz noise spikes.



Eight-Hertz Clock Signal Noise. A similar array of spikes, but a 16x higher frequency, occurs due to the spacecraft clock signal at 8 Hz. See Fig. 3 (interferogram domain) and Fig. 4 (spectral domain.) Mitigation strategy is the same as for the half-hertz noise.

Figure 3: average of 6443 unfiltered interferograms of deep space showing the 8 Hz noise from May 1, 2005 to Jun 21 2006.

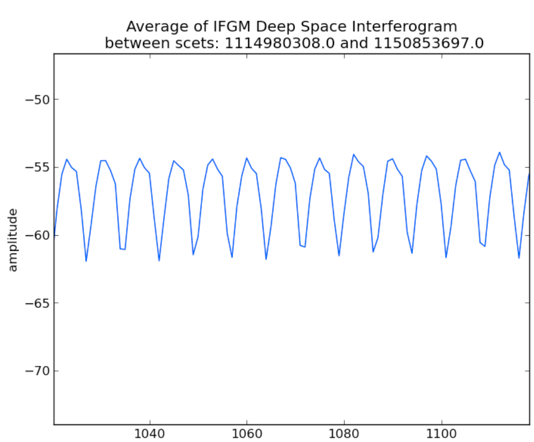
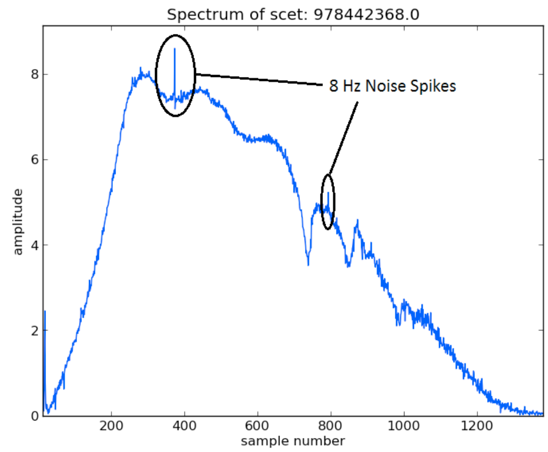
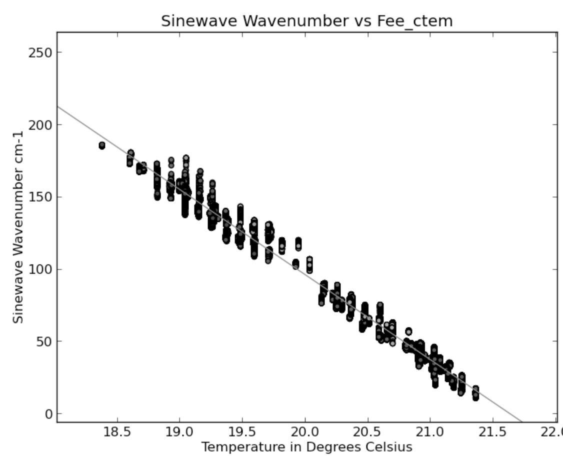


Figure 4: FP1 spectrum showing the 8 Hz spike signal at sample number ~400 and the first harmonic (16 Hz) at sample 800.



Sine wave: a sine wave of variable frequency seen on FP1 interferograms, which manifests itself as a single spike on FP1 spectra. The frequency appears to be inversely correlated with the temperature of the instrument electronics boards (Fig. 5).

Figure 5: inverse relationship between the temperature of the front end electronics (FEE) board 'C' and the frequency of the sine wave detected on FP1.



Conclusions: This paper has provided an introduction to the types of noise interferences exhibited by the CIRS spectrometer, and the mitigation strategies developed to reduce their impact. A fuller description including implications and recommendations for hardware design of future similar instruments will be given in a recently submitted paper [2].

References: [1] F. M. Flasar et al. (2004) *Space Science Reviews, 115,* 169-297. [2] C. Chan et al. (2014) *Experimental Astronomy*, submitted.