

A NOTE ON THE CHOICE OF HIRDLS CHOPPER FREQUENCY

I have been giving some thought to the criteria for choosing the optimum HIRDLS chopper frequency. The current 500/503Hz seems worth revisiting, even if only to properly document how we arrived at it in case we want to change it later ("Karlspeak").

Obvious minima are the 1/f noise knee, which seems uncertain but could be assumed to be as high as 150 Hz (?) and the need to chop at least twice as fast as the minimum required IFOV sample rate. The latter I make about 77Hz for 5 samples per IFOV at say 140 km/9 sec, but since this is not linear in km/sec for a linear angular rate (which would be easiest), let us say $80 \times 2 = 160\text{Hz}$.

If 5 samples per IFOV are still wanted, even at the max. elevation scan rate of 140km/3sec, then the min. chopper frequency is $6 \times 80 = 480\text{ Hz}$. Another choice might be $4 \times 80 = 320\text{Hz}$

The max. frequency probably depends on the required physical chopping amplitude, which could be reduced from the current baseline if we shorten the focal length of the primary telescope mirror to make the optics more compact (RAL or Roberts designs). I would guess an upper limit of 600 Hz.

However, it turns out that if we want the sample rate to be 1/n of the chopper frequency (n even), and we do not consider increasing the overall signal telemetry data rate, then the max. chopper freq (below 600 Hz) is around 500 Hz as at present.

To sum up so far, the minimum is somewhere between 160 and 480 Hz, depending on the maximum elevation scan rate for which 5 samples per IFOV is really desired. IRD para 2.5.8 specifies 5/IFOV only in global mode, but since it affects the choice of chopper frequency the Science Team might want to reconsider the wording to avoid ruling out useful options. The maximum is roughly what we have now

A totally different consideration is the 'very good or very bad' idea of locking the coolers to the Nyquist frequency, which would not appear to change the above range of chopper frequency. However, if we decide it's a bad idea, then we will definitely want to avoid having cooler harmonics at or near to the chopper frequency, in which case the lower the chopper frequency within the above limits, the less chance of a clash. The difficulty then is that we will also want to avoid running the cooler at or near to a major structural resonant frequency, and we won't know what they are until the last moment, so to speak.

The main argument in favour of running the coolers synchronously is that beating effects should be much reduced, and (hopefully) any cross-coupling will at worst give a steady offset in the signal which will calibrate out (unless it varies with scan mirror setting !!!). The main argument against synchronous operation is that it may force us to run the coolers at or near to a structural resonance, the chopper not being tuneable.

In addition to perhaps provoking some general thoughts on the above, I would request that the wording of IRD para 2.5.8 be revised if it is desired to retain the possibility of having 5 samples per IFOV for elevation scan rates greater than the global mode rate (1 scan in 9 seconds)

From: OXATM::BARNETT 5-FEB-1993 09:23:57.46
To: WHITNEY
Subj: HIRDLS chopper

John [JGW],

there are some things that I do not understand about your note on choppers:

1) why do we need to chop at lkeast twice as fast as the sampling rate; surely the requirement is that an integral number of chopper cycles fits into one signal data value - one would be sufficient.

2) I though that we had a max data rate of 85/sec; if we have a scan rate of 140km in 3 secs we cannot get the data back every 0.2 fov (=200m), and I don't think that we would expect it anyway.

Based on the above the minimum chopper frequency is 85 Hz.

One point that you should bear in mind is that for a chopper running at an arbitrary rate in relation to the data sampling, the 'centre of gravity' when viewing the atmosphere will not in general correspond to the centre of the sample time; this is why we need an integral number of cycles so that any bias is always the same.

John [JJB]

John [JJB],

You're right about the min. frequency being around 80, not 160. I think I meant 2 x chopper w/f samples, i.e. half cycles. It's academic anyway if the 1/f knee is above this.

The intention with regard to higher scan rates as discussed and as worded in the IRD is to have the option to sample a SUBSET of the channels at a higher rate than 85/sec. This option is precluded unless the chopping frequency also supports the higher rate.

I have not considered the case of a chopper running at an arbitrary rate in relation to the data sampling, as I do not think it is an option for the reason you give. Is there something in my note that gives the contrary impression ? If so it is certainly not intended.

John [JGW]