



ALMA CHANGE REQUEST

Date submitted: yyyy-mm-dd

CRE #: ALMA-00.00.00.00-000-A-CRE

TITLE: LO Spurious Signals – clarification and relaxation of requirements

(To be completed by CR Submitter/Initiator)

Description of change (detailed description of change proposed) and Justification:

System Specification #290 states that “Spurious Signals on the 1st and 2nd LO should be < -40 dBc coherent or incoherent over the frequency range from ~500 Hz to ~8 GHz offset from the carrier”. This is extremely demanding and there is no practical means of verifying it. The proposal is to change this requirement so that instead of being on the 1st LO it becomes a requirement on the signal coming out of the Warm Cartridge Assembly (WCA), i.e. before multiplication. It also takes account of the fact that spurious signals with very small offsets from the carrier are not as important as those which are further away. The purpose of this is to remove unnecessarily tight requirements on both the Master Laser and the phase-lock circuitry in the WCA.

The proposed new requirement is: “Spurious Signals (coherent or incoherent) on the outputs of the LO drivers in the WCA’s shall be < -40 dBc over the range of offset frequencies from the carrier from ~500 Hz to ~500 kHz and < -50 dBc from ~500 kHz to ~8 GHz.” It would perhaps be worth adding the clarification that: “The description ‘incoherent’ is intended to cover the case that the spurious signal is in the form of a band of noise that might mimic a weak astronomical spectral line. This means that features up to ~1 MHz in width are significant in addition to very narrow spikes. In these cases it is the integrated power in the feature that needs to be below the limits specified.” As explained below, band 5 is a special case and so an additional sentence is needed to the effect that, “For band 5 these limits should be 6 dB lower, i.e. -46 and -56 dBc”.

The requirement on the second local oscillator is unchanged, so it reads: “Spurious Signals on the 2nd LO should be < -40 dBc coherent or incoherent over the frequency range from ~500 Hz to ~8 GHz offset from the carrier.”

Justification:

It may appear that this is a tightening of the requirements, but it should be recalled that the WCA output is multiplied inside the cold cartridges to obtain the actual LO frequency. Since the multiplication factor is as high as times 9 (in Bands 9 and 10) the requirement for < -40 dBc on the 1st LO corresponds to < -59 dBc on the WCA output. This leads to a number of problems:

- a) it is almost impossible to detect any such signals on the 1st LO itself and it would be extremely difficult to do so at this low a level on the WCA output, i.e. we can’t test for conformance;
- b) in order to have sufficient bandwidth to pass the phase-switching signals, the PLL in the WCA can only provide limited rejection of the FLOOG frequency, which is in the 20 to 50 MHz range, and this would, in certain special circumstances, violate the original requirement. (In fact, for normal operation when the FLOOG is at ~30 MHz, the rejection is good enough, but for frequency switching operation, where the FLOOG can swing to as low as 20 MHz, the leakage is likely to be above < -59 dBc.)
- c) there is a feature on the Master Laser with an offset of ~310 kHz which feeds through onto the WCA output and produces a spurious signal with an integrated power of about -40 dBc.

The effect of the proposed change in requirements would be to provide a specification that is testable and which would avoid redesign of the WCA and the Master Laser.

The consequence for the scientific capabilities of ALMA is extremely small. The relevant Science requirement is number 70: “The required spectral dynamic range is 10000:1 for measurement of weak spectral lines in the presence of stronger ones, and 1000:1 for weak lines in the presence of strong continuum emission.” Note that there is nothing said in the Science Spec about how close the weak line might be to the strong one, but in reality spurious features that are . The effect of the change would be that, for offset frequencies of greater than 500 kHz, the spectral dynamic range requirement is met for all bands up to Band 7 but for Band 8 it is only 4000:1 and for Bands 9 and 10 it is ~1200:1. At these high frequencies the system noise is relatively high and astronomical spectra are very rich – i.e. they contain lots of lines – so this is even a value of 1000:1 is acceptable for the dynamic range. For offset frequencies of less than 500 kHz the guaranteed dynamic range is a factor of 10 lower than these figures, but this is of no consequence because this is less than the line-widths of the astronomical sources except in the lowest frequencies, i.e. bands 1 to 3 and there the original requirement of 10000:1 is still met for small offset frequencies. An additional mitigation is that the spurious signal occur at known frequencies so that it will be possible to check whether apparent features in astronomical spectra are due to them and (at least in principle) to remove them by a suitable cleaning process.

Band 5 has a relatively low WCA output frequency and the multiplication in the cartridge is a factor of x6. To ensure that the 10000:1 dynamic range target is met we need to put the limit on spurs at offset frequencies of greater than 500 kHz at -56 dBc. For consistency the limit on the close-in spurs is also lowered by 6 dB. It may in fact be difficult to reach that, given the Master Laser problem, but if so that could be dealt with by a waiver.

Additional information in attached documents:

The attached note shows the effects of such spurious signals.	
Impact: X Specifications X Science <input type="checkbox"/> Cost <input type="checkbox"/> Schedule <input type="checkbox"/> Safety <input type="checkbox"/> Technical <input type="checkbox"/> Other (specify):	
Description of impact: Should relieve BE of unnecessary work and make a more realistic test of conformity possible.	
Affected products to be modified: None.	
Affected documents to be revised: System Specification and presumably the Master Laser and WCA specs. Strictly a footnote should be added to the Science Specifications.	
Remarks:	
Date Submitted: 8 th April 2008	Date Decision Required: ASAP
CRE Initiator: Richard Hills	



**ALMA CHANGE REQUEST
SUMMARY STATEMENT**

Date submitted: yyyy-mm-dd
CRE #: ALMA-00.00.00.00-000-A-CRE

Summary Statement for CRE # : ALMA-00.00.00.00-000-A-CRE

Summary of Technical Impact (state concerns and/or merit):

No unfavourable impact – documentation only.

Summary of Schedule Impact:

No unfavourable impact.

Summary of Budget Impact:

None intended.

Remarks:

Why isn't there a heading "**Scientific Impact**" ?

If there were, I would say "Extremely small".

Name	Signature	Date	App	Rej	Name	Signature	Date	App	Rej
IPT LEAD			<input type="checkbox"/>	<input type="checkbox"/>	NRAO CONTROLLER			<input type="checkbox"/>	<input type="checkbox"/>
IPT LEAD			<input type="checkbox"/>	<input type="checkbox"/>	ESO CONTROLLER			<input type="checkbox"/>	<input type="checkbox"/>
IPT LEAD			<input type="checkbox"/>	<input type="checkbox"/>	JAO CONTROLLER			<input type="checkbox"/>	<input type="checkbox"/>
IPT LEAD			<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>
SYSTEMS LEAD			<input type="checkbox"/>	<input type="checkbox"/>	CCB SECRETARY			<input type="checkbox"/>	<input type="checkbox"/>
SYSTEMS LEAD			<input type="checkbox"/>	<input type="checkbox"/>	JAO PROJECT DIRECTOR			<input type="checkbox"/>	<input type="checkbox"/>