ALMA CHANGE REQUEST

Date submitted: 2012-04-30
CRE #:FEND-40.02.10.00-0000-A-CRE

TITLE:
Change Request for the Band 10 Cartridge Noise Performance (DRAFT!)

(To be completed by CR Submitter/Initiator)

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

This CRE requests changes in noise performance [FEND-40.02.10.00-00180-00 / T]

From 230 K over 80% of the frequency range

To 230 K over 60% of the frequency range

Although all pre-production cartridges are compliant with the requirement of less than 344 K for the bull-band, three cartridges out of six did not meet the specification of less than 230 K over 80% of the band as shown in Figure 1 [RD 01]. Figure 2 shows the noise performance in the worst case, which has 58% bandwidth below 230 K [RD 02].

These non-compliant performances happened due to the fact that the SIS junctions in the mixers have relatively low current density of 7-8 kA/cm^2, even though our target value is ~10 kA/cm^2 or higher. In our mixer design (and in general), the lower the current density, the lower the coupling efficiency between the SIS junctions and the waveguide feed, as described in Figure 6-9 on page 113 in Band 10 CDR design report [RD 03]. Instead, the mixer is supposed to offer wideband operation covering Band 10 frequency range with noise temperatures well below the full-bandwidth specification of 344 K. This is the case that the center frequency of the tuning circuit of the fabricated device is around the target value of 870 GHz (the center frequency of Band 10). In fact, the center frequency of the devices is shifted to lower or higher than the target value due to errors in definition of the junction sizes, variations in the complex conductivities (RF loss and kinetic inductance) of the NbTiN films, and so on, in the device fabrication process. These important parameters which directly-decide the tuning frequency of the devices can still not be well-controlled by current technologies, which is very difficult to overcome.

Another cause to increase the noise performance is thought to be excess LO noise. For example, in Figure 2, the noise increase at ~800 GHz can be seen, which may be due to the excess LO noise. The corresponding noise can be observed in measurements of noise temperature versus IF and LO frequency, as shown in Figure 3. This noise could be reduced by using a quasi-optical LO attenuator with a smaller diameter hole (larger attenuation). But simultaneously, the LO power to pump the SIS mixer will be decreased. Figure 4 shows an SIS pumped current as a function of LO frequency in full LO power operation as an example. The red line with closed squares shows optimum pumped currents for the receiver operation. The use of lager LO attenuation in the LO path would improve the receiver noise performance by decreasing the excess LO noise, but the noise performance at around 920 GHz is degraded due to a lack of LO power. Thus, it is difficult to improve the noise performance over all by changing the quasi-optical LO attenuator. More power-full LO sources will resolve this issue, as seen in the case of lower frequency bands. Or reduction of excess noise in the LO source will be necessary. However, the current LO technology limits these improvements.

Considering these situations mentioned above, the current noise requirement will need to be relaxed for the production cartridges as: The bandwidth for the 230 K noise requirement is relaxed to over 60% (instead of 80%). Another possibility has been discussed on JIRA [RD04], which is: The noise temperature requirement is relaxed to 250 K (instead of 230 K) over 80% bandwidth. The 100% bandwidth noise specification could stay the same. It should be noted that the proposed new specification or the second option would still be challenging.

Additional information in attached documents:

[RD01] FEND-40.02.04.00-0123-A-REP, “Band 10 Cartridge Manufacturing Readiness Review Technical Report”
[RD02] FEND-40.02.04.00-0110-A-REP, “Band 10 Cartridge S/N05 Acceptance Test Report”
[RD03] FEND-40.02.04.00-0039-A-REP, “Band 10 Cartridge CDR Design Report”
[RD04] http://jira.alma.cl/browse/FERFW-510

Impact: ☒Specifications ☒Science ☒Cost ☒Schedule ☐Safety ☐Technical ☐Other (specify):

Description of impact (technical, schedule, and cost):
Accepting the CRE will obviously lead to a possible negative impact on science. Rejection of the CRE on the other hand will impact on Band 10 cartridge delivery and cost. At this moment, about two years for completing the cartridge production are provisionally scheduled, assuming the acceptance of the CRE. If not accepted, it needs more

	ALMA CHANGE REQUEST	**Date submitted**: 2012-04-30 **CRE #**:FEND-40.02.10.00-0000-A-CRE
	TITLE: Change Request for the Band 10 Cartridge Noise Performance (DRAFT!)	

than twice, and the production cost will increase, accordingly.

Affected products to be modified:
FEND-40.02.10.00 (Band 10 cartridge)

Affected documents to be revised:

FEND-40.02.10.00-0002-A-SPE, "Band 10 Cartridge Technical Specifications"
ALMA-40.00.00.00-001-A-SPE, "Front-End Sub-System for the 12 m-Antenna Array Technical Specifications"
ALMA-80.04.00.00-005-B-SPE, "ALMA System Technical Requirements for 12m array"

Risk:

Remarks:

Date Submitted: 2012-04-30	**Date Decision Required:** 2012-06-08
CRE Initiator: Yoshinori Uzawa (NAOJ)	

(To be completed by CCB)

Name	Signature	Date	App	Rej	Name	Signature	Date	App	Rej
EU FE sub-system engineer			☐	☐				☐	☐
NA FE sub-system engineer			☐	☐				☐	☐
EU FE IPT Lead			☐	☐				☐	☐
NA FE IPT lead			☐	☐				☐	☐
EU/NA/EA project manager	-- if necessary --		☐	☐				☐	☐

☐APPROVED
☐REJECTED Reason:

☐ All documents have been appropriately revised Doc Spec. Signature: Date:

ALMA CHANGE REQUEST	**Date submitted**: 2012-04-30 **CRE #**:FEND-40.02.10.00-0000-A-CRE
TITLE: Change Request for the Band 10 Cartridge Noise Performance (DRAFT!)	

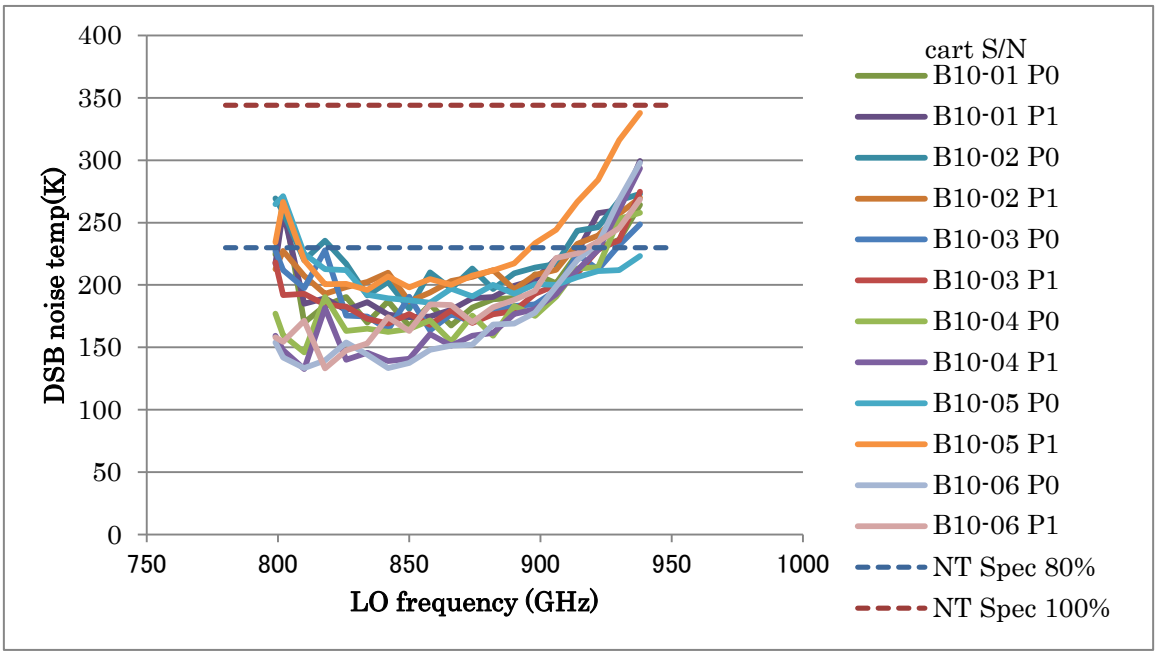

Figure 1. DSB noise temperatures of the first six Band 10 cartridges as a function of LO frequency. A blue dashed-line shows the noise performance specification of 230 K over 80% bandwidth.

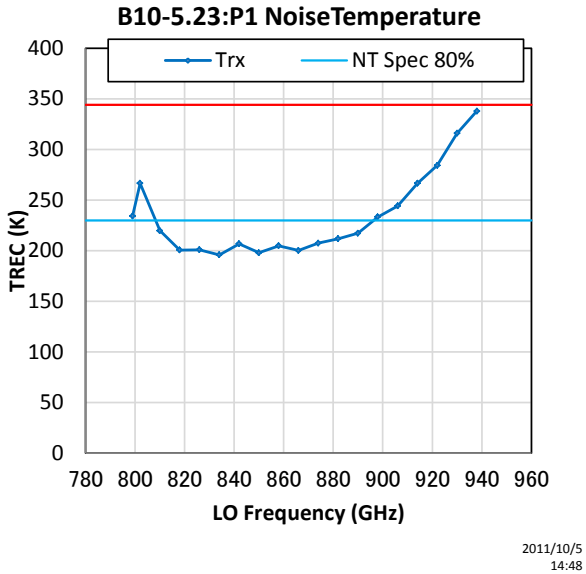

Figure 2. Noise performance of CCA10-05 Pol. 1 (the worst case of 58% bandwidth in the first six cartridges).

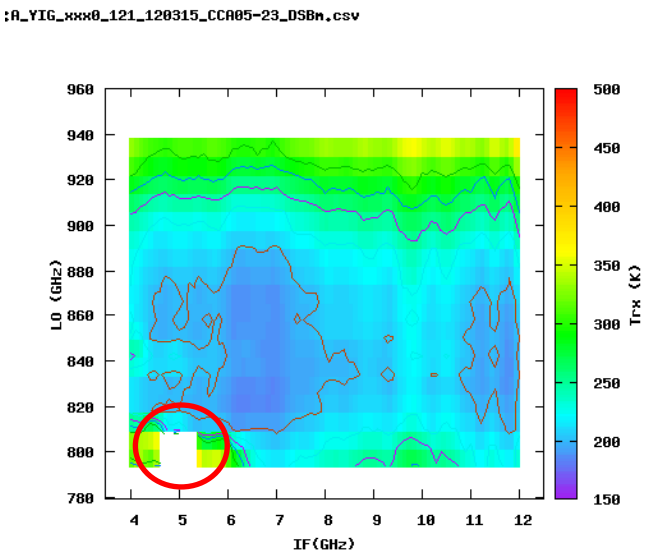

Figure 3. Noise temperature vs. IF and LO frequency of CCA10-05 Pol.1. Write region in a red circle has noise temperatures of higher than 500 K, which is attributed to excess noise from the Band 10 LO source.

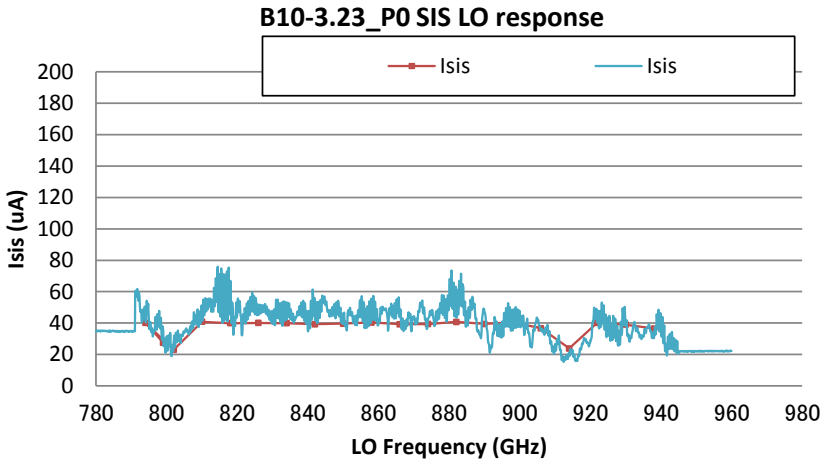

Figure 4. Measured SIS pumped current as a function of LO frequency in full power operation of CCA10-3 Pol.0. Also shown (red line with closed squares) is the pumped SIS current used for the cartridge operation.