ALMA CHANGE REQUEST

Date submitted: 2004-02-10
CRE #: ALMA-56.00.00.00-001-A-CRE

TITLE: Inclusion of 90d phase switching in the ALMA first LO

(To be completed by CR Submitter/Initiator)

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

We propose that sideband separation by 90 degree phase switching, for the bands (currently bands 9, 10, possibly 8) with double side band front ends, should be explicitly included in the ALMA project. This option improves the continuum sensitivity by a sqrt(2) factor relative to sideband suppression and doubles the observing speed for extensive spectroscopy observing projects; from the DRSP we estimate that the ALMA observing speed is doubled for an estimated 10% of the total ALMA time.

***Present situation*:**
The current situation is ambiguous. The Project book states that "side band separation is not required for ALMA" while the Review Committee recommendations after the systems PDR (Garching, February 2000) mentions "Sideband separation in DSB-mode will be possible for integration times in multiples of 1 sec". The feature is available in the correlator hardware. The Science Software Requirements mention it explicitly (SSR 2.3-R12, in ALMA-70.10.00.00-002-I-SPE) and it is thus included in the Computing IPT plans.

Justification for CRE:
For DSB receivers there are three observing strategies:

(a) True DSB operation: the delay tracking is made accurate enough so that the two sidebands add in phase. This is quite difficult to achieve (as said in *System Design Description* sec. 4.4), only works for point sources with flat spectrum, and only the real part of the visibility is measured.
(b) Side band suppression by frequency offset: the source emission in the image sideband is nullified by offsetting the first and second LO's by the same small amount. This simple scheme is the default for SSB or 2SB receivers.
(c) Side band separation by 90 degree switching. This is the method current mm-wave interferometers are using. The visibilities in both sidebands are measured, each with the same sensitivity as the single sideband is measured in mode (b). The noise in the USB and LSB results are independent so they can be averaged to improve sensitivity.

Main advantage: (c) brings a net improvement for continuum observations, increasing the sensitivity by sqrt(2) relative to sideband suppression. It also doubles the observing speed compared to mode (b) for extensive spectroscopy, like frequency surveys of line-rich sources. In the Design Reference Science Plan, continuum-only programs in band 9 account for 8% of the overall total ALMA time. Including line surveys, and programs with a substantial continuum fraction we may well reach 10%.

Other advantages of option (c):

- The sensitivity for reference phase calibration (aka fast switching) is improved by sqrt(2).
- The side-band gain ratios are measured twice faster in (c) relative to (b); this ratio has to be measured for accurate amplitude calibration, in particular for single-dish measurements, in all bands with DSB operation.

Requirements of option (c):

- the data rate is doubled (but this is a low contribution to the average data rate).
- there is a minimum integration time (2s) to allow for a complete cycle of switching functions.
- the synchronization of the 90 degree switching has to be accurate, between the antennas and the correlator.

The feasibility of (c) with the presently designed and planned ALMA hardware is established: see ALMA memos 287. 385, 391). This situation may however not continue, as detailed design and construction progress, if a clear decision to include this feature is not taken.

Additional information in attached documents:
Proto-memo on sideband separation (S.Guilloteau & R. Lucas, attached).

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

Description of impact:
Improve the science throughput by a factor of 2 in time for a large fraction of projects in bands with DSB front ends (9,10, possibly 8)., concerning an estimated 10% of total ALMA observing time.

Affected products to be modified:

Affected documents to be revised: Project Book, System description
Remarks:
Date Submitted: 2004-01-xx | **Date Decision Required:**
CRE Initiator: Robert Lucas

(To be completed by CCB)

Name	Signature	Date	App	Rej	Name	Signature	Date	App	Rej
CCB Secretary			☐	☐	**CCB Chair**			☐	☐
CCB #1			☐	☐	**CCB #2**			☐	☐
CCB #3			☐	☐	**CCB #4**			☐	☐
CCB #5			☐	☐	**CCB #6**			☐	☐
Project Manager			☐	☐	**Project Director**			☐	☐
☐APPROVED ☐REJECTED Reason:									
☐ All documents have been appropriately revised		Doc Spec. Signature:					Date:		