10-24-00

From: "Larry D'Addario" <ldaddari@tuc.nrao.edu>
Date: Tue, 24 Oct 2000 17:09:17 -0700
To: Dick Sramek <dsramek@aoc.nrao.edu>
Cc: "Larry D'Addario" <ldaddario@zia.aoc.nrao.edu>,
"Marc D. Rafal" <mrafal@cv3.cv.nrao.edu>,
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Skip Thacker <sthacker@tuc.nrao.edu>,
John Webber <jwebber@tuc.nrao.edu>,
Darrel Emerson <demerson@tuc.nrao.edu>,
Eric Bryerton <ebryerto@cv3.cv.nrao.edu>
Subject: Re: ALMA LO Planning and Coordination Teleconference

Dick,

Additional items:

2. Central synthesizer range; see my email of sep-30 and oct-04.
3. Who is doing what? Based on my document http://www.tuc.nrao.edu/~ldaddari/loOrganization.pdf can we decide whether the assignments of responsibilities are correct?

Regarding agenda item 1, Eric's memo on LO Driver packaging, I will forward some correspondance that we had. In addition, I offer the following for your consideration:

Unlike the conclusion in Eric's "Discussion" section, I favor Option

3. Even better would be Option 3A, which is similar:

3A: Like Eric's Option 3, but

Band 1 has a completely separate PLS assembly, using a 27-33 GHz YTO and no active multiplier chain (AMC) at all.

Bands 2-10 use a common YTO covering 16.5-26.0 GHz driving only one AMC, which has a doubler and power amplifier. This is followed by a 1:9 PIN switch in WR22 waveguide, feeding all 9 warm multiplier assemblies (WMAs). For bands 2-7, the WMA is as shown in Eric's drawing, with a doubler and power amp. For bands 8-10, the doubler is replaced by a tripler.

This selection of frequencies limits the driver's total multiplication factor to 4 (vs. 6 in Eric's scheme) for bands 2-7 and to 6 (vs. 8) for bands 8-10. Also no multiplier for band 1. All this has advantages that I can discuss at the meeting. The total parts count is rather drastically reduced.

- Larry

10-24-00

From: "Larry D'Addario" <ldaddari@tuc.nrao.edu>
Date: Tue, 24 Oct 2000 17:11:43 -0700
To: To: Dick Sramek <dsramek@aoc.nrao.edu>
Cc: "Larry D'Addario" <ldaddario@zia.aoc.nrao.edu>,
"Marc D. Rafal" <mrafal@cv3.cv.nrao.edu>,
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Eric Bryerton <ebryerto@cv3.cv.nrao.edu>
Subject: digest of mail for LO meeting

From: "Larry D'Addario" <ldaddari@tuc.nrao.edu>
To: bshillue, dsramek, aperfett
CC: demerson
Subject: ALMA LO synthesis
Date: Sat, 30 Sep 2000 14:35:06 -0700 (MST)
Message-ID: <14806.23690.390086.674788@heineken.tuc.nrao.edu>
MIME-Version: 1.0
Content-Length: 2147
Content-Type: text/plain; charset=us-ascii

The current block diagram shows the 1st LO synthesis beginning from a microwave synthesizer with range:

8.600 to 10.425 step .005 GHz

which was intended to cover the full ALMA reference range of 27.3-33 and 68.5-122 GHz without any gaps, using harmonic numbers of N=3..12.

It turns out that this range is wrong. It fails to cover band 1, which requires tuning 27.3 to 33.0 GHz. This could be fixed by extending the top end to 11.0 GHz and using N=3 for that band. However, it then gets to 132 GHz at N=12, which is more than is needed, and only to 121 at N=11, just short of what's needed. Further study and optimization leads to:

Ignoring band 1 -

a. N=7..11, fsyn=9.705..11.091 GHz -> 67.935..122.00 GHz with no gaps
b. N=6..10, fsyn=10.457..12.200 GHz -> 62.742..122.0 GHz
c. N=7,9,11 only, fsyn=8.626..11.091 GHz -> 60.384..122.0 GHz
d. N=6,8,10 only, fsyn=9.150..12.200 GHz -> 54.9..122.0 GHz

For band 1 -

e. fysn= 6.75 to 8.25 GHz -> band 1 at N=4
f. fsyn= 9.10 to 11.00 GHz -> band 1 at N=3

So we have various options, but the frequency range of the microwave synthesizer needs to be revised. Question for all of you: Among the following considerations, which are most important to getting the best performance/cost?

1. Minimize harmonic number [select (b or d) and f]
2. Minimize range of microwave synthesizer [select a and f]
3. Use only even harmonics in laser synthesizer [select d and e]
4. Use only odd harmonics in laser synthesizer [select c and f]

In the absence of any comments, I will be inclined to select c+f, yielding:

Microwave synthesizer	8.626 to 11.091 step .005 GHz
Harmonic numbers used	3, 7, 9, 11

Output ranges

(including 125MHz offset in laser synthesizer)

N=3	26.003..33.398 step .015 GHz
N=7	60.507..77.762 step .035
N=9	77.634..99.944 step .045
N=11	95.011..122.126 step .055

Remember that the .005 GHz step size is intended to ensure phase-unambiguous synthesis with a 5 MHz reference. We could get away with allowing phase ambiguity, especially for the TI, but it would preclude certain ways of using subarrays.

Please send comments.

- Larry

From: Eric Bryerton <ebryerto@nrao.edu>
To: "Larry D'Addario" <ldaddari@tuc.nrao.edu>
CC: dsramek@nrao.edu, ldaddari@nrao.edu, mrafal@nrao.edu, rbrown@nrao.edu, rbradley@nrao.edu, tkerr@nrao.edu, gmoorey@nrao.edu, jpayne@nrao.edu, bshillue@nrao.edu, sthacker@nrao.edu, jwebber@nrao.edu, demerson@nrao.edu
Subject: Re: First LO Packaging Options
Date: Fri, 13 Oct 2000 13:39:04 -0400

Hi Larry,

Thanks for the quick reply.

Larry D'Addario wrote:

>
- Eric,

>
- Your document "Notes on LO Driver Options" is very well done, and is
- quite valuable in moving us forward in the design process.

>
- I have a few comments (mostly just questions):

>
- . The prescaler board seems rather large, and the PLL board seems too
- small (assuming that each contains the components that I think it
- does).

>
The prescaler is rather large for only 2 chips and a coupler, isn't it. I've had second thoughts about this and now think that the coupler and divide-by-8 prescaler should be integrated in the AMC block since it's at a rather high frequency (18 GHz) to be running around on a board and it makes me slightly uncomfortable to have 12 to 18 GHz on microstrip in the cartridge with everthing else. In this case, the prescaler board can be eliminated and the AMC will be slightly larger with a coax output containing 1.5-2.4 GHz to be routed to the LO controller. This should have little effect on the total imprint. The PLL board is probably ok. If it needs more room, we can stand it an inch off the board and extend it to the YTO.

>
- . Table 1, footnote 2: (IF range of band 3 for SIS) This disagrees
- with statements made by John Webber in recent meetings, where he
- reports that the SIS design for band 3+ (85-116) does not require a
- compromise of instantaneous bandwidth. From a scientific and system
- design perspective, I believe that the extention from 89 to 85 GHz
- should **not** be pursued if it requires compromising the bandwidth.
- Therefore, LO planning should be based on the 4-12 GHz IF for all
- bands.

>

Pass

>

- . Table 2, "AMC": The various "AMCs" are not all the same; in fact,
- they are vastly different. So why are all assigned the same cost?
- For Option 3, there is no AMC at all for Band 1, and the other AMCs do
- not include the final doubler. For other options, you include the
- doubler in the AMC. This confuses the accounting and makes me wonder
- whether the cost comparisions are reliable. The total costs are
- sufficiently close among all options that this sort of thing is
- important.

>

The only cost difference between the AMCs will be in terms of labor, I believe. The blocks will cost about the same, the chips and Cuflon boards are basically negligible. I would estimate a $200 reduction in labor cost for one less stage of multiplication. This doesn't make a huge difference either way. The costs are surprisingly close among the options, which may be the important point, and it might even be fundamental, I don't know.

>

- . Table 2, footnote 6, "waveguide runs": I can't find any bends nor
- any flex piece in any of your drawings, so I suppose these are for the
- interconnection between the PLS and the WMA.

>

Correct. Each waveguide run from the PLS to WMA is assumed to consist of 2 straights, 2 bends, and a flex piece.

>

- . All drawings: The AMCs are all shown the same size, and quite
- small. Some of them need to contain a doubler and tripler, or two
- doublers, along with at least one power amplifier, all in waveguide.
- Except for Option 3, they all need to contain a final doubler in
- addition to these. Can you justify the indicated size? Indeed, the
- final doubler alone (as shown in Option 3) is nearly as big as the
- whole AMC (including this doubler) as shown in Option 2 (in height,
- it's actually 0.1in bigger!). Your selection of 2 over 3 is heavily
- dependent on the claim that the WMAs are the same size, but this seems
- unlikely to be correct, as well as the claim (also questionable) that
- it costs no more.

>

The dimensions of the AMC are based on similar AMC components available from Millitech (http://www.millitech.com/mmw/datasheets/AMC_REV03_C_6-5-00.PDF). The interesting thing to note is that the 6 designs they specify (ranging from a doubler with 26.5 to 40-GHz output to a x6 AMC with 75-100 GHz output) all have the same outside dimensions (2"x1"x0.6"). I don't intend to buy the AMCs from Millitech, it just serves as a guideline to estimate size. And based on some preliminary designs, in-house AMCs will not be far off even for a x8 AMC. Shrinking the doubler in option #3 really doesn't help the size (nowhere near as much as eliminating the waveguides), same is true for opt #2.

>

- . Why are some waveguide components shown as interconnected with
- straight WG sections of about 25mm length, while others are shown as
- having the blocks butted together? This makes a large difference in
- the total volume occupied.

>

Components that we build ourselves can be designed to allow for cascading with other blocks and I tried to do this where I saw an obvious advantage in terms of shrinking the imprint of the WMA. The RF mixer/IF preamp is a Spacek part, but we are thinking of doing this ourselves (I have a design going to the shop today) and perhaps integrating it in one block with the AMC and 3-dB hybrid. This would further shrink the volume and probably allow the photomixer to be butted against the rf mixer.

>

- . How large are the WMAs in the third dimension, not shown?

>

Sorry, this is an important detail that I forgot for all components.

Briefly, the "heights" are:

YTO+driver = 1.65" + SMA connector
AMC = 1.0"
RF mixer/IF amp (opt #1)= 0.75"
RF mixer/IF amp (opt #2)= 2.5"
everthing else in WMA approx. 1"

>

- . Why is the 3dB hybrid of Option 4 shown as bigger than both the > (same) hybrid and the doubler in Option 3? These hybrids seem to be > the biggest thing in the WMA; that's strange. Surely they need not be > the same size for all bands. Is a 3dB hybrid really appropriate, as > opposed to a 10dB coupler? If the hybrid/coupler is closely coupled > with the doubler, as in Options 1-3, then since we're fabricating both > why not build them in the same block, saving considerable space?

>

The 3dB hybrid in opt #4 is extended to allow for the 3rd waveguide connection. It could be made smaller with an external waveguide bend. (I have shown the waveguide bend inside the block, operating under the guideline of minimizing waveguide connections and parts.) Since I have shown the coupler before the power amp, we probably want 3dB coupling rather than 10dB, since power level at this point will be on the order of 0dBm). And the gain of the power amp is enough to compensate for the difference.

>

- . OTOH, one of the most important mechanisms for getting spurious
- signals into the LO is through the finite isolation of the final
- hybrid/coupler; that isolation becomes terrible if the input port (the
- doubler output) is poorly matched. Therefore, an isolator might be
- needed between the doubler and hybrid/coupler.

>

I haven't thought of this. We were considering integrating the AMC and the hybrid, but we'll take this into account.

>

- . Why is the PLL IF shown as 165.25 MHz? It should be 31 MHz. You
- then do not need a 125 MHz reference to the PLL board.

>

I had thought, based on http://www.tuc.nrao.edu/~ldaddari/alma.pdf pg. 4, that a double downconversion was taking place. The first mixing with 125 MHz and the second with 31.25MHz + FF from the DDS. Please correct me if I'm wrong.

>

- . Table 2, photomixer: Cost estimate is very low, unless prices for
- chips fall substantially from present levels. This cost seems to
- include only the cost of machine a WG block and labor for mounting the
- chip, as if the chip itself has negligible cost.

>

I did assume negligible cost for chip. I would welcome an estimate;

I'll ask Bill Shillue. As far as comparisons go, this only effects option #5.

>

This is a first cut and if you see more places where cost or volume can be saved or advantages and disdvantages that I have overlooked, do not hesitate to point them out.

- Eric

From:	"Larry D'Addario" <ldaddari@tuc.nrao.edu>
To:	Eric Bryerton <ebryerto@nrao.edu>
CC:	bshillue
Subject:	Re: First LO Packaging Options
Date:	Tue, 17 Oct 2000 08:21:25 -0700

Eric,

My apologies, you are right. I thought that this had been revised to eliminate the second conversion, but it was really the Test Interferometer block diagram ('testsystem.pdf') that shows it this way. I will soon be working on revisions to 'alma.pdf'.

My current thinking is that a PLL offset of 31 MHz is enough, and therefore only a single conversion is required. This depends on the noise spectrum of the (photonic) reference signal. In certain lasers, there can be enhanced noise at 10s of MHz from the carrier, and for that reason we might want to get further away, e.g. 156 MHz. But my understanding is that this is not the case for the lasers we intend to use.

Bill, could you comment on this? Compare the block diagram in 'alma.pdf' page 4 with the one in 'testsystem.pdf' pages 5-6.

- Larry

From: "Larry D'Addario" <ldaddari@tuc.nrao.edu>
To: dsramek, wbrundag, mrevnell, bshillue, aperfett, greiland
CC: demerson
Subject: ALMA microwave synthesizer frequencies
Date: Wed, 4 Oct 2000 13:38:27 -0700 (MST)
Message-ID: <14811.38211.880588.958107@heineken.tuc.nrao.edu>
MIME-Version: 1.0
Content-Length: 1699
Content-Type: text/plain; charset=us-ascii

Based on the discussion given in my email of 2000-Sep-30 and on some followup meetings here in Tucson, the frequency range required for the variable-frequency reference to the laser synthesizer is now revised to be:

8620 to 11080 MHz, 5 MHz steps, unambiguous phase after re-tuning.

(Cf. old specification of 8600 to 10425 step 5 MHz.)

This allows the laser synthesizer to provide continuous frequency coverage for all 10 ALMA bands, using harmonic numbers of 3,7,9,11 only. The microwave synthesizer is expected to operate from a 5 MHz reference, which it receives from the Central Reference Generator.

There will be one of these for each subarray.

Please use the above information in any future design work and in any new drawings or other documentation. Old documents should be revised as soon as it is convenient to do so. The system block diagram will soon be updated to reflect this change.

For the test interferometer, the same range is required, but it is desired to have smaller step size (1 MHz max, preferably 0.1 MHz) so as to support fine tuning of the holography transmitter. We will give up the phase-ambiguous-retuning requirement to achieve this.

FYI, a similar synthesizer is needed as part of the LO system of the holography receiver. A commercial device has been selected:

Micro-Lambda Model MLSL-0811, for which we have a quote of $3200 each. This device is adequate for the holography receiver, but it is not phase-unambiguous nor does it have low enough phase noise for use in the central LO of the array. It might be marginally good enough for the central LO of the TI.

- Larry

PS: Micro-Lambda device specs are at
http://www.micro-lambda.com/mlsl_3_ghz.htm