Submillimeter Array Technical Memorandum

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An Estimate of Parts Needed for the Expanded 8 Antenna SMA Correlator

The addition of two antennas to the SMA array will impact the digital and analog portions of the correlator quite differently. On the analog side of the correlator, the number of 2 GHz IF bands will increase from 12 to 16. As a consequence the analog hardware will increase by roughly 33%. While the digital hardware will see an increase in baseline calculations from 15 to 38. This would imply an expansion of about 87%.

To the first order, these numbers are reasonable, but they do not tell the whole story. This document will try to firm up some of the number associated with the expansion. This discussion will consider individual subsystems and give some idea of how the expansion connects into the standard 6 antenna correlator system.. To clarify this discussion, the read should refer the block diagrams of the Correlator.

In the quantities give for the required subsystems, there is a finally entry which reflects the additional spares needed for the expanded correlator. With the large number of electronic assemblies in the system and the remoteness of the site, it is important that we keep a reasonable number of spares on-hand to allow sub-system exchanges at Mauna Kea, thereby avoiding detailed repair work on the mountain. We will try to limit all serious sub-system repair work to Hilo or Cambridge. This circumstance drives us to keep a fairly large number of spares module. Nominally, the spares count will range from 10-30% of the needed units. The number are will vary to reflect the relative importance of a given module and it's likely tendency to fail.

I. Analog Section

Processing in the analog section is essentially parallel in nature, so the addition of 2 antennas will be relatively easy. Thus for most of the hardware the expansion will simply require the production of additional units. There are a few complications associate with common signals. The largest is the LO distribution network. Since LO's are common for all antennas, the distribution network must be expanded to generate the extra copies of the signal.

A. Downconversion/Sampler hardware

The 2 GHz IF band from a receiver is filtered and mixed down in two stages into 24 contiguous baseband signals. After frequency conversion, the 24 baseband signals are individually sampled and encoded for transmission to the cot-relator. A single IF Chassis (approximately 12" x19" x 31") will convert the IF signal from a fiber optic input and encode the sampled data onto 6 ribbon cables which attach to the correlator. Within the analog downconversion chassis is a number of subsystems. The following table gives a breakdown of the major modules in this chassis, and the required quantities.

The expansion will require 4 more chassis. These expansion chassis are exactly identical to the original 12 units. Naturally, there will be some savings in non-recurring engineering charges. (For example, PC board fabrication) if these 4 additional units are done together with the original 12 units.

Major Modules	SAO Part #	Standard qty needed	Extra needed for expansion	With spares
A.1. First downconverter	1036716	12	4	6
A.2. Second downconverter	1036717	72	24	28
A.3. Analog Chassis	105670 1	12	4	5
A.4. Power Supply Unit	1036718	12	4	6

B. LO Generation/distribution

The LO is common for all telescopes. so it is unnecessary to purchase extra LO's for the 8 antenna system. However, the distribution hardware must be altered to make extra copies of the LO for use in the additional downconverters. In some cases this expansion requires simply adding extra modules, but in one case there is no hook for excess capacity, so a minor change is needed in an existing splitter module.

Major Modules	SAO Part #	Standard qty needed	Extra needed for expansion	With spares
A. 1. High Freq. LO Splitter 4-way	1036715	24	6	8
A.2. Low Freq. LO Splitter 6-way	1036719	56	16	18
A.3. Low Freq 2-way divider	TBD	4	0	0
A.4. Low Freq 3-way divider	TDB	0	4	5
AS. Sampler Clock Distr.6-way	TBD	12	4	5
A.6. Sampler Clock Distr. 12-way	TBD	1	0	0
A.7. Sampler Clock Distr. 16-way	TBD	0	1	2
A.7. LO Dist Chassis	TBD	4	1	1

C. Correlated Noise Source

This test source is common to all IFs (thereby explaining why it's correlated). This unit uses a very similar distribution chain as the high frequency LOs. Again, the original source does not need to be duplicated. The only requirement is to expand the distribution chain.

Major Modules	SAO Part #	Standard qty needed	Extra needed for expansion	With spares
C. 1. High Freq. LO Splitter 4-way	1036715	4	1	1

D. System Level Analog

Naturally, there will be many miscellaneous system pieces which require change or duplication. For Example, wiring for the AC power, distribution of some timing signals (10 msec), monitor cables and extra racks.

Major Modules	SAO Part #	Standard qty needed	Extra needed for expansion	With spares
D.1. Racks	TBD	5	2	2

II. Digital Section

The expansion will physically double the number of chassis required in the digital section. Thus, the original correlator has 6 chassis in 3 racks, while the expanded correlator will be 12 chassis in 6 racks. The various pieces of physical hardware will be duplicated, but there will be some subtle differences in internal quantities and organization.

After sampling, data is transmitted over the sampler cables to the digital section of the correlator room. The first board encountered in the electronics is the the receiver board, which is responsible for antenna-level processing such as the geometric delay. To minimize the difficulty in expanding the correlator to 8 antennas, the receiver boards have been designed with an expansion plug. By inserting a daughter board in this plug, a copy of the sampler signals is created for distribution to the expansion chassis. Figure #1 and #2 gives a sketch of the sampler/receiver board wiring for both the standard 6 antenna array and the expanded array.

After the receiver board, data is distributed by the backplane and mezzanine board to create the necessary copies of the signal which are required for the baseline calculations. Each correlator board only performs two baseline calculations, thus in the standard array every sampler signal must be driven to at least 3 boards to calculate all the baseline products. For the expanded array, the 2 extra baseline calculations are performed in the expansion chassis.

With the exception of the daughter board to re-generate the sampler signals. the other digital boards are identical in the expansion chassis. The only other change is a jumper which must be moved on the Mezzanine board to modify the signal distribution (See SMA Technical Memo #8 1)

A. Correlator boards

The Correlator Boards house the ASIC correlator chips and DSP computers used for real-time processing of the signals. In the standard 6 antenna array, a chassis is filled with 8 correlator boards. They calculate 15 baseline products, with 7 boards doing two crosscorrelations and one board performing a single crosscorrelation. In the expanded array, the original calculations are unaffected. The extra chassis are used to determine the additional 13 crosscorrelations. With some rearrangement of signal distribution, it is possible to stuff the expansion chassis with only 7 cot-relator boards. The boards themselves are unaffected. (See SMA Technical Memo #81)

Major Modules	SAO Part #	Standard qty needed	Extra needed for expansion	With spares
A. 1. Correlator Boards	102680 1	48	42	49

B. Receiver Boards

The receiver boards provide an interface between the A/D converters and the correlator. It also implements a number of important control function such as the digital delay and sampler threshold monitors. As indicated in figure #2, the expansion chassis must be stuffed with S receiver boards to handle all 8 baselines.

Major Modules	SAO Part #	Standard qty needed	Extra needed for expansion	With spares
B. 1. Receiver Boards	1026804	36	48	56
B. 1. Expansion Daughter Bd	1026805	0	36	42
B.2. Sampler Cables	1840005	72	24	30
B.3. Expansion Jumper Cables	1840006	0	72	SO
B .4. Hi-Resolution Cables	TBD	72	96	106

C. System level Digital

Sandwiched between the receiver board the correlator board is a pair of signal distribution boards called the "mezzanine" board and backplane. The backplane is actually constructed of two pieces, first an off-the-shelf VME backplane and the second a custom-built board. To complete the expansion chassis will require 6 copies of the various pieces of hardware and electronics.

Major Modules	SAO Part #	Standard qty needed	Extra needed for expansion	With spares
C. 1 .Custom Backplane	1026802	6	6	8
C.2.VME Backplane	TBD	6	6	7
C.3. Mezzanine Board	1026803	6	6	8
C.3. Chassis/Fan/PS	TBD	6	6	7
C.4. Crate Controller	TBD	6	6	7
C.5. Digital Racks	TBD	3	3	4

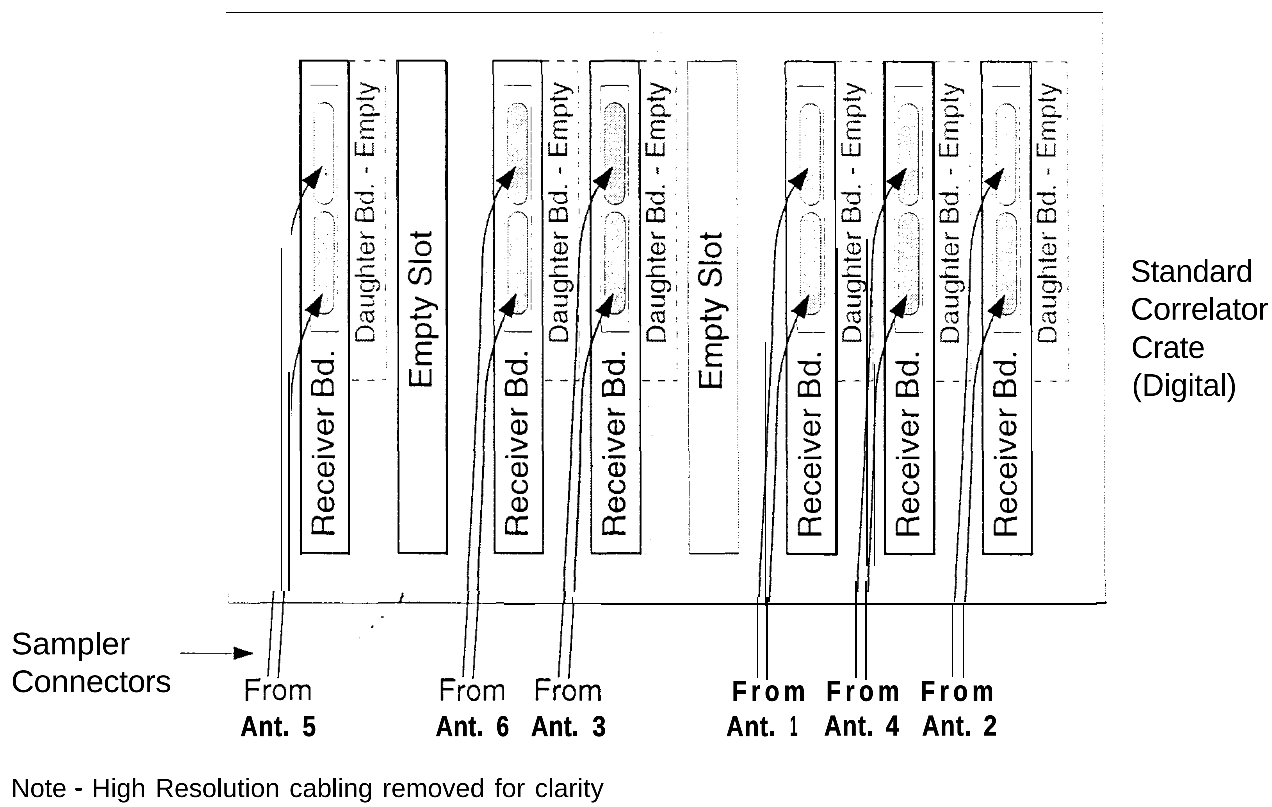

Figure 1 - Sampler to Receiver board connections for standard 6 Antenna Correlator

III. Other changes.

A Software Revisions

The "embedded" portion of the software should be unaffected by the expansion. This includes the software in the downconverter microcontroller and the correlator board DSP. However, further up the food chain will require substantial work to accommodate the extra data. The crate controllers

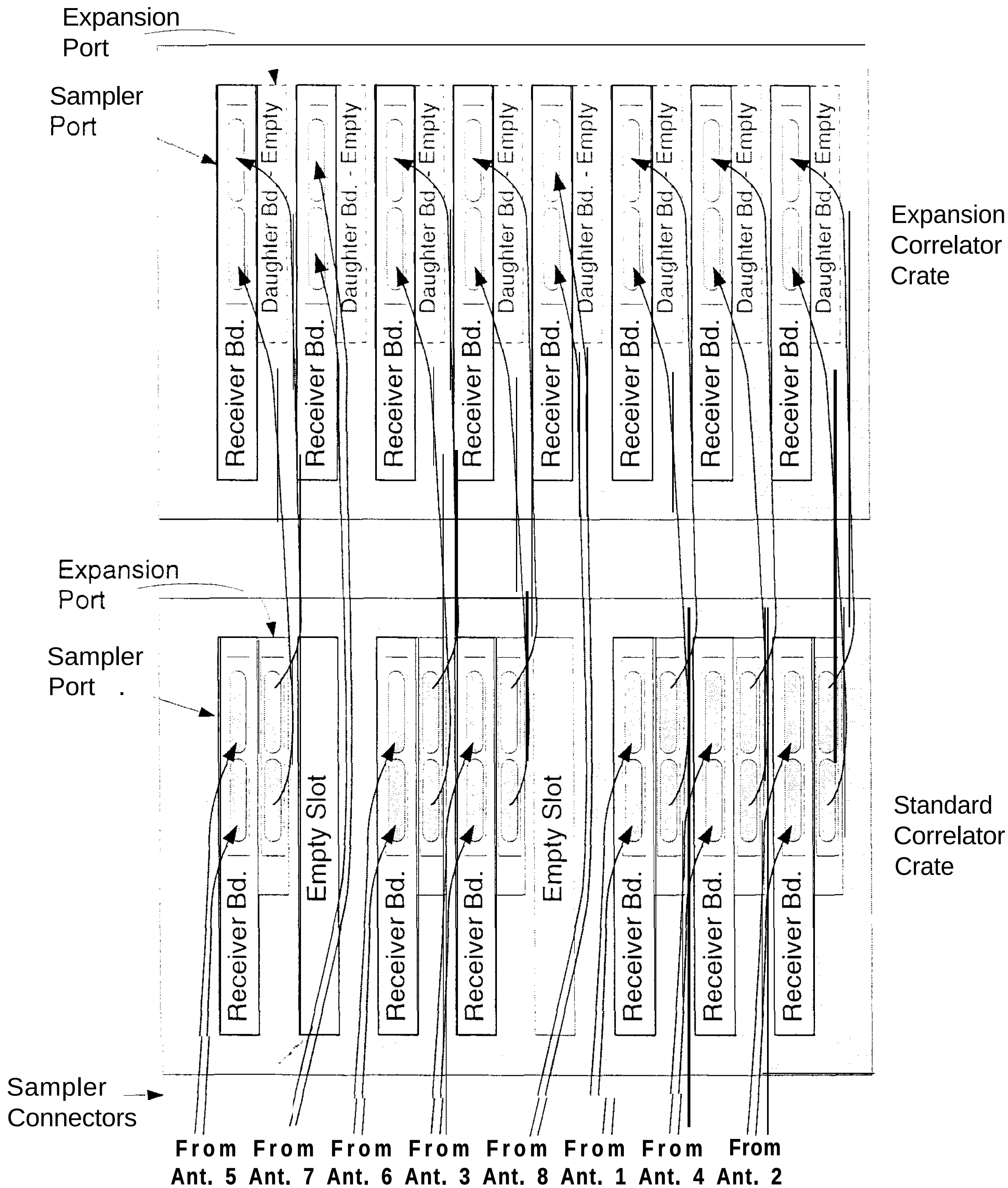

Figure 2 - Sampler to Receiver board connections for Expanded 8 Antenna Correlator

will need to handle the division of the baseline calculation into two chassis.

There will be some work in the crate controller to handle the changes in the receiver board interface. In the standard correlator every receiver board is attached (by an asynchronous RS-485 port) to a microcontroller in the downconverter. Thus, the crate controller has a fixed communication channel which it must maintained. In the expanded correlator this one-to-one correspondence is broken. Thus, the software must be slightly more complex to handle the two cases.

The majority of the software revision will be required in the the post processing stage. With the extra baselines, the data rate increases substantially. Also, the telescope control software must generate the additional delay, and phase rate information for the extra telescopes. The extent of this revision is quite difficult to predict because, at the moment, the 6 antenna software is far from complete.