LOCAL OSCILLATOR SYSTEM DESIGN

L. R. D'Addario
1983 December 26

This memo describes the current design for the local oscillator system at each VLBA station. The frequency coverage specified in VLBA Memo No. 295 assumes this design. It is based on the double-conversion scheme originally described in Memo No. 254, where all input bands are converted to a single I.F. at 500 to 1000 MHz, and from this I.F. to baseband. Coarse tuning (100 MHz steps) is provided in the first L.O. and fine tuning (10 kHz steps) is provided in the baseband converters. For the 1.3 cm and 0.7 cm bands, it is necessary to use two conversions to get to the I.F. in order to insure adequate image rejection.

All the components of the L.O. system and their locations (either the vertex room or the equipment room) will be specified here. Performance specifications and more detailed designs for critical components will be given in a later memo. The fine-tuning oscillator is not included, since it will be constructed as part of each baseband converter.

FREQUENCY CONVERSION SCHEME DETAILS

To clarify the frequency conversion scheme, simplified block diagrams of the front ends are given in Fig. 1. For most bands, a single L.O. input in the range 2 to 16 GHz is needed. A single synthesizer will cover this range in steps of 100 MHz except for the multiples of 500 MHz. For front ends with input bandwidths less than 500 MHz, only one synthesizer setting is used; for the 2 cm and 3.6 cm front ends (and the optional 2.8 cm one), one setting above the band and one below the band are used to extend the coverage to 1000 MHz. Note that, except for the special mode at 3.6 cm described below, the frequency diversity is always 500 MHz, and the I.F. bands of the two polarizations both correspond to the same band on the sky. Of course, baseband channels on opposite polarizations may be on different sky frequencies within the available 500 MHz.

At 1.3 and 0.7 cm, the inputs are first converted to 10.15 GHz with a tunable L.O., and then to the I.F. band with a fixed L.O. at 9.4 GHz. At 1.3 cm, the required first L.O. (11.1 to 15.6 GHz) can be provided by the 2-16 GHz synthesizer. At 0.7 cm, a special oscillator is required at around 33 GHz, and it must be tunable over at least 500 MHz to provide the specified 1.0 GHz of frequency coverage; we are planning an oscillator which can be locked to four frequencies in the desired range.

At 3.6 cm, switches are provided to support a special mode in which the two polarizations are converted by separate first L.O.s. This allows frequency diversity greater than 500 MHz, provided that the split polarization is acceptable. Such a capability is desired for geodesy experiments, which are expected to use this band preferentially. One of the L.O.s is the usual synthesizer, and the other is the fixed 9.4 GHz oscillator (also used at 1.3 and 0.7 cm); each can be connected to either polarization. By tuning the synthesizer to 7.4 GHz, 1000 MHz of frequency diversity is obtained; but note that the front end performance is specified only over an 800 MHz bandwidth.

The 50 cm and 90 cm bands are not shown in Fig. 1. The former is already in the I.F. band, so no conversion is needed. The latter will be upconverted using a fixed L.O. at 500 MHz.

IMPLEMENTATION

A block diagram of the current design is given in Figures 2 and 3. Only components which are part of the L.O. system are included, and all interfaces with other systems are believed to be indicated. The allocation of components to particular modules and racks has not yet been decided, but most of the blocks in the figures will probably become separate plug-in modules.

In the station control building, there will be two rooms devoted to operational hardware, called the equipment room and the control room; roughly, they will contain r.f. equipment and digital equipment, respectively. All of the control building L.O. hardware will be in the equipment room. (Other rooms in the building will be used for storage, maintenance work, etc.)

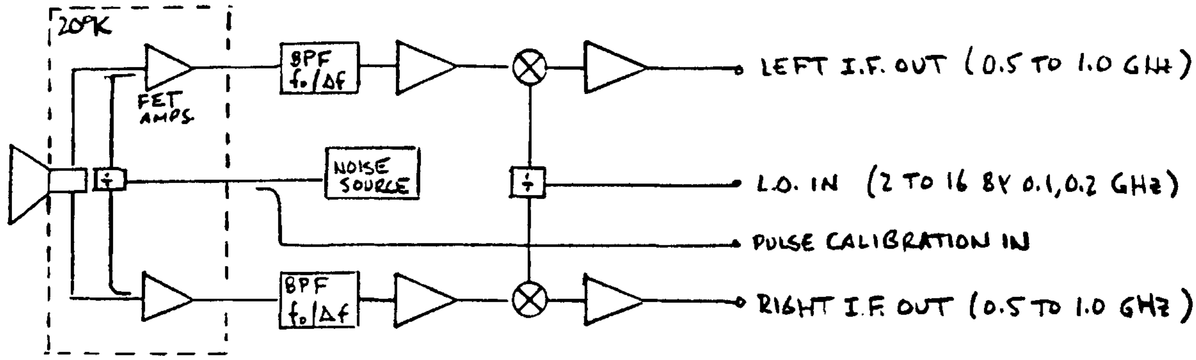
The equipment room portion is concerned with the generation and distribution of reference signals. The hydrogen maser will provide stable references at 5 MHz and 100 MHz; these will be passed to the day/time clock and the digital data acquisition equipment, respectively (both in the control room). Additional reference frequencies are needed at 10 kHz for the baseband converters (equipment room) and at 500 MHz for the first L.O.s (vertex room). These will be generated by a divider and multiplier, respectively; both of these are expected to require a tightly temperature-controlled environment for adequate phase stability. The 5 MHz reference is also used by the delay calibration pulse generator (vertex room).

Three reference signals (5, 100, and 500 MHz) will be transmitted to the vertex room via identical, buried, coaxial cables. (The four I.F. cables from the vertex room should also be identical to these.) The electrical lengths of the 5 MHz and 500 MHz lines will be monitored by round-trip phase meters. The 100 MHz signal is a secondary reference for the first L.O.s.

In the vertex room, the 5 MHz reference is used only for the delay calibrator. The 100 MHz and 500 MHz references are distributed to four phase-locked oscillators. In each case, the oscillator is locked to a harmonic of 500 MHz plus or minus 100 or 300 MHz. Two 2-16 GHz synthesizers are provided in order to support dual-band operation; the roles of the two can be interchanged by a transfer switch, so that single-band operation can continue if either one fails. The various L.O.s are distributed to the required receivers by three 4-way switches, and these include spare outputs for future receivers or system modifications.

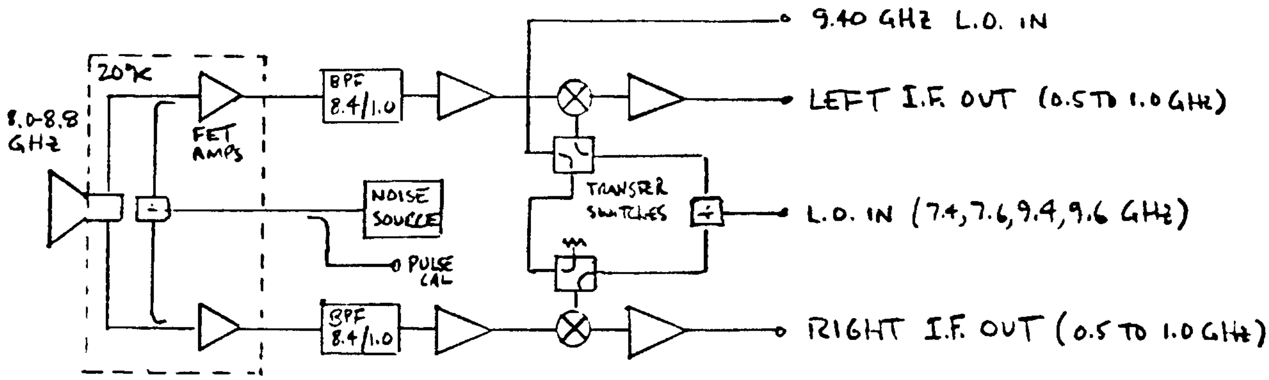
Dual-band operation is not supported for all possible pairs of bands, but it is believed that all pairs of interest are covered, as well as others. Note that 3.6 cm split mode and 13 cm are simultaneously supported. The connections to the switch outputs indicated in Fig. 3 are somewhat arbitrary, so the pairs of bands which can be observed simultaneously are easily changed.

The choice of 500 MHz for the primary first L.O. reference results in two advantages over the use of a lower frequency: harmonics generated in the vertex room are rather widely spaced, and none falls within the I.F. band (except for the delay calibrator, which is at a low level); and the line length can be monitored to higher precision. The latter is important because line length variations are expected to make the largest contribution by far to instabilities of the L.O. phase and of the I.F. delay.

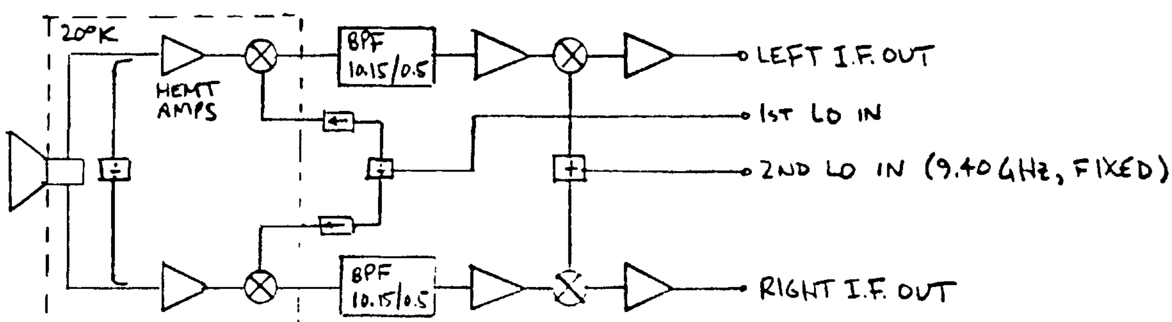


(a) STANDARD RECEIVER

BAND	f_0	Δf
20 cm	1.550	.400
13	2.35	.50
6	4.80	.50
2.8	10.7	1.0
2	14.9	1.0

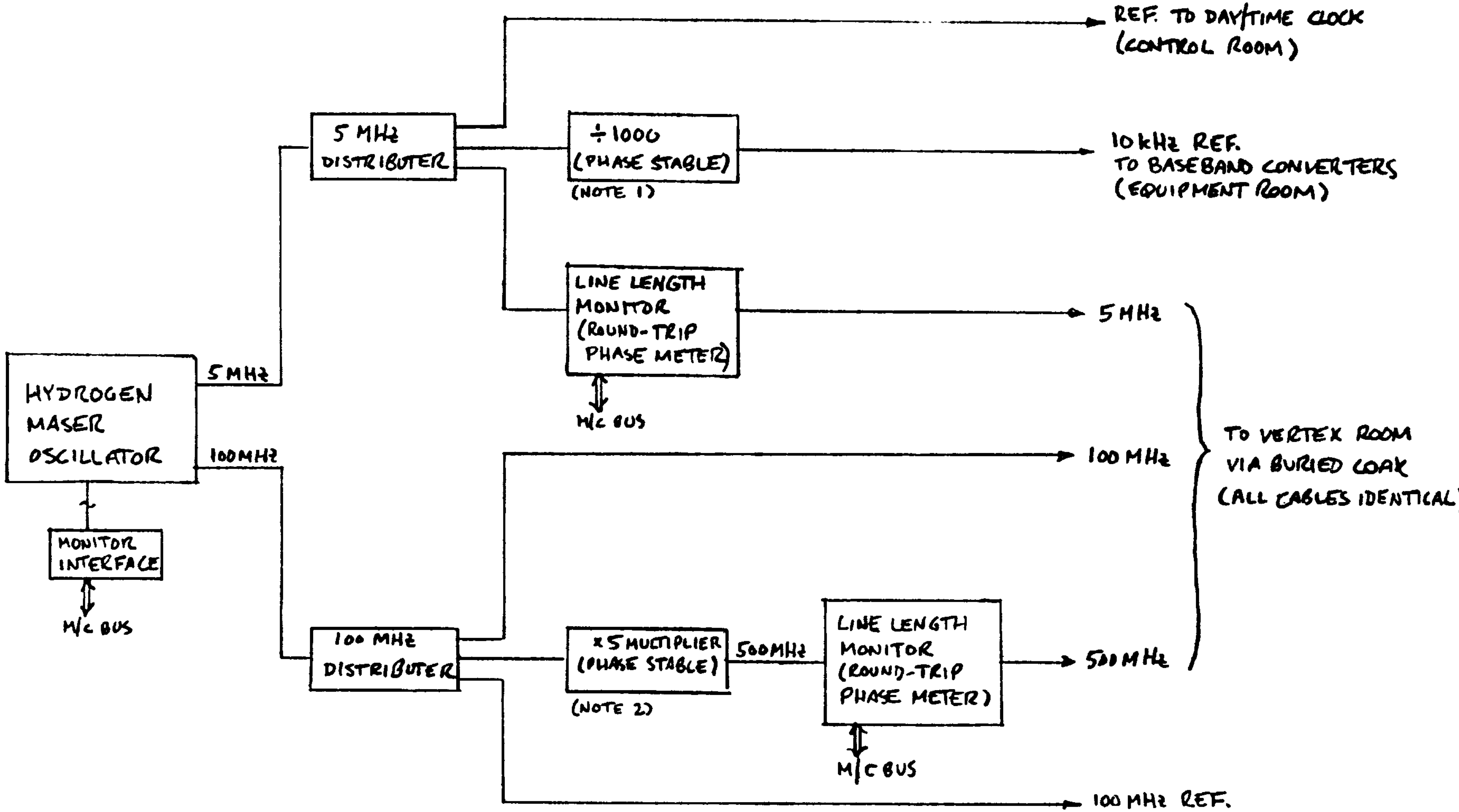


(b) 3.6 CM RECEIVER



(c) 1.3 AND 0.7 CM RECEIVERS. 1st LO: 1.3 CM – 11.1 TO 15.6 BY 0.1, 0.2 GHz
0.7 CM – 32.4, 32.6, 32.9, 33.1 GHz

FIGURE 1: VLBA Front Ends, simplified block diagrams.



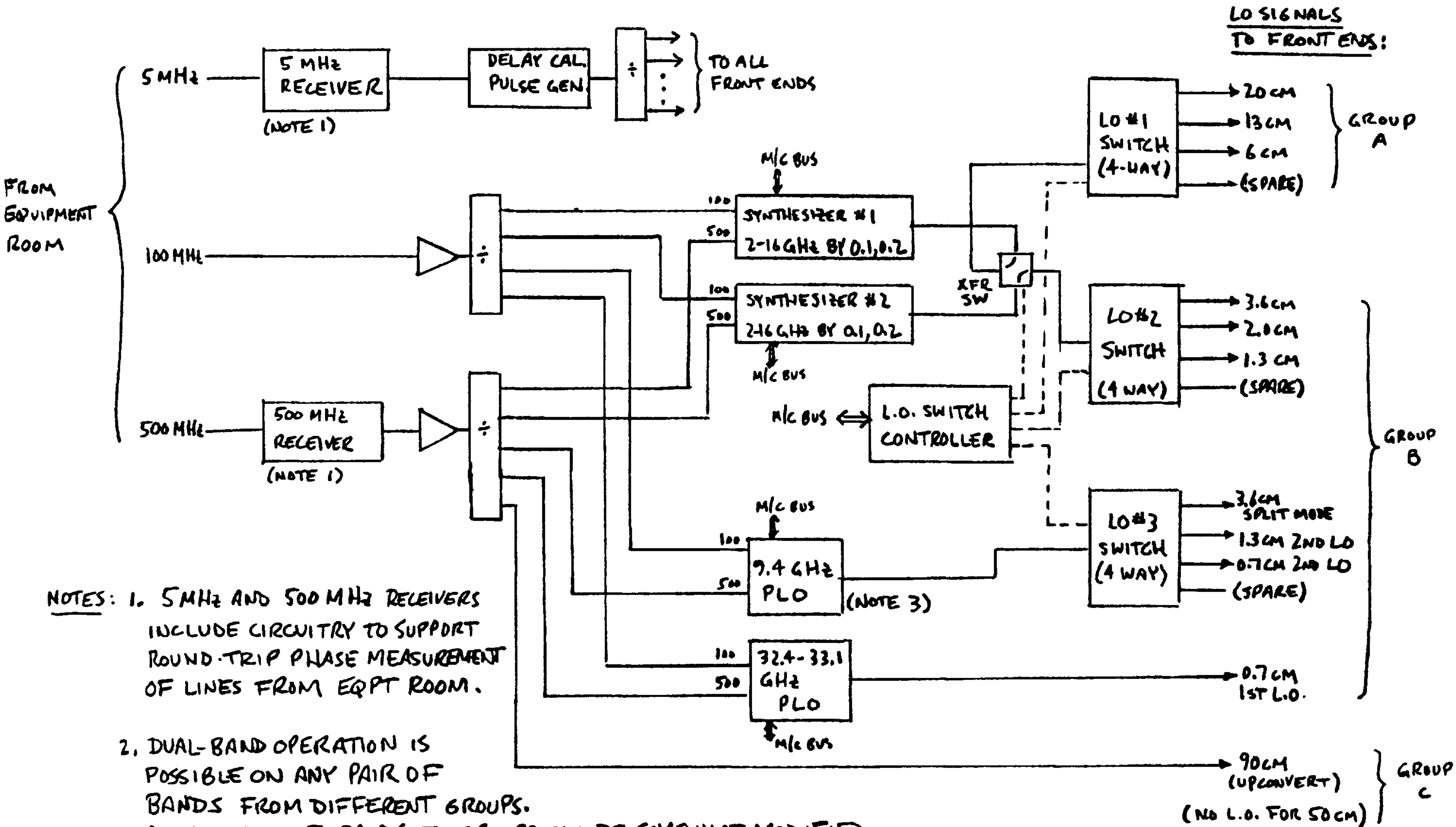
NOTES: 1. AN ADDITIONAL MASER OUTPUT AT 10 kHz MIGHT BE AVAILABLE, IN WHICH CASE THE FREQUENCY DIVIDER COULD BE ELIMINATED.

2. AN ADDITIONAL MASER OUTPUT CONTAINING A 100 MHz COMB MIGHT BE AVAILABLE, IN WHICH CASE THE x5 MULTIPLIER COULD BE REPLACED BY A 500 MHz FILTER.

VLBA LOCAL OSCILLATOR SYSTEM · EQUIPMENT ROOM PORTION, BLOCK DIAGRAM

831216 LRD

FIGURE 2: L.O. Block Diagram, Equipment Room Portion



NOTES: 1. 5 MHz AND 500 MHz RECEIVERS INCLUDE CIRCUITRY TO SUPPORT ROUND-TRIP PHASE MEASUREMENT OF LINES FROM EQPT ROOM.

2. DUAL-BAND OPERATION IS POSSIBLE ON ANY PAIR OF BANDS FROM DIFFERENT GROUPS. ASSIGNMENT OF BANDS TO GROUPS CAN BE SOMEWHAT MODIFIED IF NECESSARY.

3. IN CASE ADDITIONAL FLEXIBILITY IS NEEDED IN THE FUTURE, THE 9.4 GHz PLO CAN BE REPLACED BY A THIRD SYNTHESIZER.

VLBA LOCAL OSCILLATOR SYSTEM: VERTEX ROOM PORTION BLOCK DIAGRAM

831216 LRD

FIGURE 3: L.O. Block Diagram, Vertex Room Portion