Pulse Calibration Detection in the VLBA

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February 8, 1989

A pulse calibration system is under development for the VLBA. A preliminary plan for the RF portion has been described in VLBA Electronics Memo No. 622. At present the VLBA system contains only a minimal capability for the detection (or retreival) of calibration signals. This system is located in the formatter and detects only two signals simultaneously within the total of eight or more basebands used. (The number of baseband channels within a Data Aquisition Rack (DAR) could be as many as 28 for a rack outfitted with 14 Baseband Converters, if the required number of sasmplers is added. However, the most commonly used number for VLBA observations is likely to be eight, which is equal to the maximum number of baseband signals accepted simultaneously from a single playback recorder at the VLBA correlator.) The baseband signal frequencies that can be detected with the present system are limited to:

sample frequency/8N for 2-level quantization
sample frequency/16N for 4-level quantization,

where 1 < N < 32,768. For further details see VLBA Aquisition Memo No. 108. This system is adequate for diagnostic tests at the antenna stations, and for limited phase calibration if the detectors are time-shared between the basebands. It was thoughtfully included in the formatter before the decision to include a full pulse calibration system was made.

To allow full use to be made of a pulse calibration system, a detection system with greater capacity and flexibility than the present one is highly desirable. Some details of such a system were discussed at the VLBA Advisory Committee meeting in November 1988. Because of manpower limitations it is unlikely that any further work will be done on a new calibration detection system before the final construction stages of the project. The purpose of this memo is to record current thoughts on the requirements.

The design of the correlator does not readily accomodate the addition of a calibration detector, because the data streams will have had varying delays applied to them by the time that they emerge from the playback interface. Note however that the correlator itself can be used for detecting and measuring calibration signals, but not while performing its usual role of correlating noise signals. Thus it can provide calibration detection on a separate pass of the tapes. This capability may be useful for special observations and tests, but not for routine observations. Thus it appears that the detectors must be located at the stations. (Ideally they would be at the correlator to minimize complexity at the antennas, and to avoid a later add-on to the Data Aquisition racks, particularly those manufactured and sold commercially.) The detectors will therefore either be on cards added to the formatter, or in a separate module located in the DAR. The output data in the form of amplitudes and phases of the detected signals will be recorded with the monitor data.

A good choice for the number of signals that can simultaneously be detected would be eight per formatter or DAR, i.e. one for each of the baseband signals that will commonly be used in VLBA observations. Timesharing would be necessary only for cases where more than four baseband converters are used within a DAR. However it should be possible to time-share so that two or four calibration signals can be detected within each baseband channel, if required.

The present practice with the NUG systems is to set the local oscillators so that the calibration signal is at the same frequency (10 kHz) within each baseband. For the VLBA it would be preferable to avoid this restriction. On the other hand it is likely to be rare that calibration signals would have to be at different frequencies within all eight basebands. In many cases (not including bandwidth synthesis) the basebands will be divided between opposite polarizations, so there will be no more than four input frequency bands. For bandwidth synthesis observations, the local oscillator frequencies can always be adjusted within the 1 MHz or 5 MHz intervals between the signals, so that the calibration signals are not at more than four different frequencies in the various basebands. Thus four would seem to be a good compromise for the maximum number of different calibration frequencies to be detected simultaneously in any one DAR.

The detectable baseband frequencies should not be confined to the low end of the bands, since these may not accurately represent the mean phase or delay variation, particularly if the variation results from temperature variation of the baseband amplifiers. Thus the frequencies should be variable up to 16 MHz, and in steps of 10 kHz to match the tunability of the local oscillators.

The most convenient location for the calibration detectors would be in the formatter, since this would eliminate the need to route sample pulses to a special module. There are some spare slots in the formatter, and the existing detector cards can be removed to make further room, if required. However, if the formatter will not accomodate all of the circuitry required, the best scheme might be to put the phase detector parts of the system (the multiplying and integrating circuits which are relatively simple) in the formatter and put the reference frequency generators in a separate module. One would then run eight reference signals (two quadrature outputs for each of four frequencies) from this module to the formatter, but would avoid any additional cabling of the data sample streams between modules. The reference signals from the frequency generators would be in the form of digital samples, possibly using three-level quantization.

The details of the final scheme to be used do not have to be firmly settled at this time, but it is important to have some plan in mind for the pulse calibration detectors. It would be useful to have any comments from experienced pulse calibration users if they feel that the scheme outlined above is not adequate or is overly elaborate.