National Radio Astronomy Observatory
Socorro, NM

VLA ELECTRONICS MEMO. 224

AN ALTERNATIVE TO F15 MODULE — Phase switching 3200MHz LO (using Walsh Function) to eliminate spurious signals at L-band

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June 14, 1995

In the present VLA L-band system the RF signals are upconverted to frequency of about 4.5 to 5 GHz by mixing with a LO signal of 3200MHz from F2 Module. The 4.5-5 GHz signals are down converted to IF around 1025 MHz by mixing with LO signals of 3.5 to 4 GHz from L6 (2-4 GHz Synthesizer) Modules which have fringe rotation and phase switching using Walsh functions. Spurious signals in 4.5 to 5 GHz are produced by the second harmonic of 3200MHz beating with RF (i.e. 2*3200-f_r) in the first mixer. To eliminate these spurious products it was suggested to use direct conversion from RF to 1025 MHz IF (VLA Electronics Memo. 223) using LO from the L6 Modules. A module based on this conversion scheme has been designed and is called F15. However as the phase switching is introduced after the spurious signals are produced we donot get any advantage of the phase switcing in reducing these spurious signals. If the 3200MHz LO signals are phase switched using Walsh functions these spurious signals (2*3200-f_r) could be (mostly) eliminated. Here we describe how to do this and its advantages over the F15 approach.

Consider phase switching the 3200MHz LO signals in different antennas by 180° using Walsh Functions as we do for the L6 signals. The spurious products generated by 2*3200-f_r will not have the desired phase change, and later when we remove the phase shift from the signals, the spurious signals from various antennas will become incoherent if the switching signals in various antennas are orthogonal to each other. Therefore we have to only ensure that the spurious products are sufficiently low to not effect the system temperature appriciably. This is readily achieved for most practical situations (as $2f_l - f_r$ term is generally more than 20-25 dB below $f_r + f_l$ term in most balanced mixers used at these frequencies).

The 3200MHz LO signal in a F2 module is produced by a VCO. The VCO output is mixed with 3000MHz from the L3 module and the resulting 200MHz signal is phase locked to 200MHz from the L2 Module. If we introduce a 180° phase shift, controlled by a Walsh function signal, on the 200MHz reference from L2, then we will have the 3200MHz signal with desired phase switching on it. The loop bandwidth of the PLL in F2 is about 100 kHz, and therefore phase transients should not cause any phase lock problem.

The phase switching of the 200MHz reference from L2 can be achieved by switching in a $\lambda/2$ cable (at 200MHz) controlled by Walsh function. However it may be difficult to achieve exact 180° phase switching this way. This may cause a small closure errors. Alternatively one can tap out a 400MHz signal from the LO system and use a flip-flop (multivibrator) to produce 200MHz whose phase can be controlled by a Walsh function signal. This should produce exact 180° phase switching and therefore phase switching of L6 signals may not be necessary. It means one can use existing Walsh function signals for phase switching 200MHz instead of L6 signals (for L-band observations). The flip-flops will have to be controlled to synchronize zero and 180° phase shift in the antenna and at the backend.

This scheme has some advantages over F15s:
1. F15s may generate some spurious signals (e.g. $2f_r - f_l$ and $3f_r - f_l$) though these should be considerably lower than 2*3200-f_r products generated now. Undesired components produced in this scheme should be incoherent from various antennas and therefore should not contribute in the correlated outputs.
2. This scheme should be cheaper (materials and labor) to implement than F15s. F15 scheme inverts the spectrum, unlike existing frequency conversion, and therefore during the transition both systems (old and new) have to be working. As this scheme does not alter the existing frequency conversion we are familiar with all its problems, whereas a different frequency conversion scheme may have other problems about which we are not aware.
3. This provides phase modulated 200MHz which may be useful for generating phase switched F3 and F12 LO signals.