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good — go ahead

Choice of First IF for the MMA

A. R. Kerr 29 May 1999

Larry D'Addario's recent memo asks how the 4-12 GHz IF band, mentioned in several MMA documents, was selected; whether some other band, *e.g.*, 1-9 GHz, or 8-16 GHz might not have advantages; and points out that the choice of first IF affects groups at multiple sites working on IF-related matters. The 4-12 GHz band was proposed, tentatively, by me at the July '98 MMA Review in Tucson, and the printed material distributed at that meeting shows some calculations of SIS receiver performance with (i) a 4-12 GHz IF using no isolator between mixer and preamp, and (ii) an 8-16 GHz IF using an isolator. I arrived at the 4-12 GHz band during some design simulations with S. Weinreb using his MMICAD models of InP grounded-source and grounded-gate MMIC amplifiers. The following were taken into account in arriving at the tentative choice of 4-12 GHz.

The MMA specification requires 8 GHz IF bandwidth with lowest practical receiver noise temperature. Note that such a wide bandwidth is required mainly for continuum observations; many line observations will require substantially less, and will doubtless be done in the IF range giving lowest system noise.

4-8 GHz in simulations?

The overall system gain should be flat across the 8 GHz band. In the (non exhaustive) simulations I have done, it was difficult to achieve a gain variation better than +/- 1 dB with the lower band edge below about 4 GHz.

A 2 K increase in IF amplifier noise temperature, *e.g.*, in going from a 4-12 GHz IF to an 8-16 GHz IF, is likely to add ~8 K to the overall receiver noise temperature.

The effect of IF parasitic capacitance and inductance associated with the RF choke and RF tuning circuit in most SIS mixers (see MMA Memo 205), can limit the IF bandwidth over which acceptable receiver performance is obtained (see MMA Memo 114).

A bias circuit must be included between the mixer and preamp. We do not yet know how much additional parasitic capacitance and inductance that will add, nor its effect on the IF bandwidth -- I am working on that at present.

Using an isolator between mixer and IF amplifier adds substantially to the receiver noise temperature (for an example, see my presentation at the July '98 MMA Review). This is because the IF thermal radiation from the termination on the third port of the isolator is partly reflected from the mixer's IF port which is (generally) not well matched, and adds to the effective IF noise. (Note that trying to match the IF load to the output of an SIS mixer results in an RF input impedance with a negative real part -- not desirable for stable operation.

Sideband separating receivers are desirable for the MMA (see MMA Memo 168 and 206). This requires an IF quadrature hybrid to combine the signals from two component mixers. Commercial multi-octave (room temperature) quadrature hybrids are available, *e.g.* from Merrimac, but at lower frequencies, hybrids with 8 GHz bandwidth have increasing amplitude and phase mismatch. Based on a cursory study of commercial (room temperature) specifications, it appears that bands lower than 4-12 GHz will compromise sideband separation. A secondary consideration is the physical size of the IF quadrature hybrids; a commercial 1-9 GHz unit is 4.65" long, compared with 1.72" for a 4-12 GHz hybrid.