III-5. A NEW MILLIMETER MIXER USING BULK SEMICONDUCTOR (AND ITS RADIO FREQUENCY BOLOMETRIC PROTOTYPE)*

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We have carried out an analysis and demonstrated experimentally mixing in the 8-millimeter region using non-linear effects in a bulk semiconductor. In a manner analogous to optical heterodyne mixers, it is not required that the element have instantaneous response to the individual RF cycle, but merely that the time constant be sufficiently short for the intermediate frequency output. The barrier capacitance, and small size inherent to point-contact and similar diodes is eliminated, so that this type of mixer will inherently operate at frequencies well into the submillimeter region. Furthermore, it can be easily matched over broad bandwidths.

In order to check the method of operation, a low-frequency prototype was constructed and tested using a bolometer operating at room temperature as the non-linear element. The mixer was operated at 1 mc, with a 1000-cps intermediate frequency and operated essentially as the analysis predicted, exhibiting very good linearity and dynamic range. A conversion loss of 25.0 db was obtained, compared to a calculated value of 27.2 db.

Millimeter mixing was demonstrated in the 8-millimeter region using n-type Indium Antimonide as the bulk semiconductor mixer element operating at liquid helium temperatures. The non-linear effect utilized involves the increase in the effective temperature of the free electrons due to the absorption of millimeter power. The hot electrons have a higher mobility thus increasing the conductivity of the element.

Since no significant lattice heating is involved, the time constant is near 10^{-7} seconds and flat output response up to the megacycle region is achieved. The InSb element was mounted in K_a-band waveguide and readily matched over the 30 to 40 gc band with a VSWR below 2.5 for the initial experiments. IF output was via 50-ohm coaxial line connected to two ohmic contacts on the InSb element. Experiments were carried out at 4.2°K and 1.8°K, with and without a magnetic field which serves to increase mixer impedance and increase non-linearity. Mixing was obtained at a variety of frequencies from 30 to 40 gc. A conversion loss of 24.5 db was measured at 1.8°K, with a signal frequency of 32.0 gc, and an IF frequency of 1.5 mc. When corrected for mismatch losses and other effects, a conversion loss of 16.5 db is calculated.

Further experiments are in progress.

In the paper, the low-frequency prototype mixer and millimeter mixing experiments will be described and the results will be compared to the analysis.

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