INFRARED FREQUENCY SYNTHESIS WITH JOSEPHSON JUNCTIONS

D. G. McDonald, A. S. Risley, J. D. Cupp, and K. M. Evenson
Cryogenics Division
NBS-Institute for Basic Standards
Boulder, Colorado 80302

At the present time, harmonic multiplication and mixing of infrared radiation with microwave sources is best accomplished in point contact W-Ni room temperature devices and Nb-Nb superconducting Josephson junctions. Due to its room temperature environment the W-Ni point contact is much simpler to use than a Josephson junction, but the superconducting device has unique characteristics and we shall emphasize those.

The simplified form of Josephson junction theory is well known and its principal qualitative features are as follows:

1. The junction oscillates at a frequency ω_J proportional to the time averaged voltage V_o across its terminals, i.e., $\omega_J(\text{MHz}) = 484\ V_o(\mu\text{V})$.

2. Since the junction current and voltage are not linearly related, the junction also acts as a harmonic multiplier and mixer.

For frequency measurements in the infrared both of these properties are used. The self oscillation ω_J is used as a diagnostic tool to insure that the junction is working properly at the frequency of interest but it is not used directly for the most accurate frequency determinations. For these we take advantage of the second characteristic above and, rather remarkably, we have found that by simply applying a very pure microwave source ($\approx$ 10 GHz) to the junction we can generate a harmonic comb that extends to at least the 400th harmonic of this source. This fact was verified by applying an infrared laser to the junction and observing the beat signal between the high harmonic of the microwave source and the fundamental laser frequency.

In the most elaborate development of this technique, using a traveling wave maser as a preamplifier for the beat signal, we hope to observe a beat between the $\approx$ 1100th harmonic of the klystron and the 10718 GHz water vapor laser.

In summary, the most important point is that by using only a Josephson junction and a tuneable microwave source, any frequency whatsoever up to $\approx$ 4000 GHz and probably even up to $\approx$ 11000 GHz can be synthesized.