SECOND HARMONIC TUNING EFFECTS ON IMPATT DIODE OSCILLATOR NOISE CHARACTERISTICS

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Summary

A method of controlling the conventionally noisy FM characteristics of an IMPATT diode oscillator by properly terminating the second harmonic frequency is described. The result is also characterized by a self-locking mechanism with a resulting mechanical tuning range, via the second harmonic circuit, of up to 100 MHz at lower X-band. Effects of second harmonic tuning on IMPATT reflection - type amplifier operating bandwidth is also discussed.

Experimental Results

An X-band IMPATT diode oscillator has been designed in which the fundamental frequency and the second harmonic frequency circuits are orthogonalized. It has been experimentally observed that by independently tuning the second harmonic circuit, the fundamental frequency output signal's FM noise characteristics can be varied over a wide range. Additionally, the fundamental frequency of operation can be mechanically tuned by the second harmonic circuit. The maximum tuning range thus far observed has been 100 MHz at 7.0 GHz.

Data will be presented showing the FM noise spectrum of a 7.84 GHz oscillator as a function of the second harmonic circuit tuning condition. For this particular oscillator, the range of FM noise spectra could be varied from 200Hz/1KHz (Figure 1a) at 1KHz from the carrier. for the best condition to over 1200Hz/1KHz (Figure 1b) for the noisiest case. An illustration of the frequency tuning capability of the oscillator will also be presented.

A silicon, 200 mw, X-band rated, IMPATT diode was used to obtain this particular set of data. The circuit was operated using several other silicon IMPATT diodes; and the same second harmonic effects were observed in all cases.

A Q_{EXT} of 15 for the X-band portion of the circuit was measured by observing its locking bandwidth from an externally applied signal.

The X-band circuit consists of a coaxial 50Ω line with three quarter-wavelength tuning transformers and a second harmonic coaxial choke. The second harmonic circuit consists of a reduced-height waveguide section terminated with variable short circuits. The cutoff frequency of the waveguide is 11.8 GHz. The IMPATT diode is mounted at the intersection of the two physically orthogonal circuits. The diode chip is mounted in a conventional microwave diode package.

The second harmonic circuit tuning is accomplished by varying the position of the waveguide variable short. In order to confirm that it is the second harmonic load impedance that is being tuned, the diode was replaced by a suitable probe and the load impedance was measured at the X-band frequency and at the second harmonic frequency as a function of the waveguide variable short position. The load impedance at X-band remained unaffected by the waveguide circuit. On the other hand, the load impedance at the second harmonic frequency was a direct function of the variable short position. Starting at a given variable short position corresponding to the noisiest condition, subsequent variation of the short first reduces the noise spectrum. Continued variation of the short produces a continuous sweep of the fundamental frequency until the edge of the tuning band is reached, indicating the existence of a self-locking mechanism. At this point the output signal snaps back to its original frequency with the noisiest characteristics.

In addition to the above results, it has been experimentally observed that in general the fundamental frequency output power level varies as a function of the second harmonic load condition. Variations have been observed to extend from the diodes rated output power level down to zero.

The circuit has also been tuned so as to operate as a reflection-type amplifier, with the second harmonic effects investigated. In this particular case, a 500 mw X-band rated silicon IMPATT diode was used as the active element. For most tuning conditions observed, the second harmonic circuit showed an effect analogous to that of a high Q wavemeter inserted at the amplifier output. However, over a small range of tuning conditions, the second harmonic circuit exhibited a marked influence over a considerable portion of the operating frequency band. In this particular case the amplifier was operating from 6.5 to 8.0 GHz and the second harmonic circuit tuning exhibited an enhancement over the latter 450 MHz of this band.

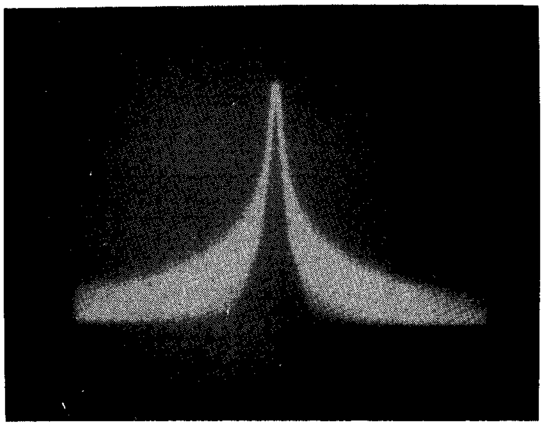

Fig. 1(a) IMPATT Oscillator At Noisiest Condition. Vertical 10 db/cm, Horizontal 1 MHz/cm, f_o 7.84 GHz.

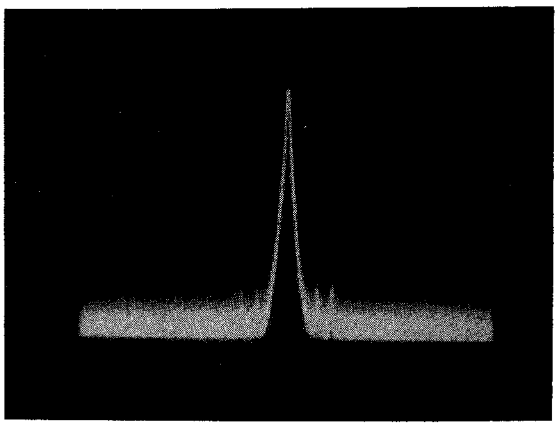

Fig. 1(b) IMPATT Oscillator At Least Noisiest Condition. Vertical 10 db/cm, Horizontal 1 MHz/cm, f_o 7.84 GHz.