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141GHz Generation by a GaAs Gunn Oscillator Up-Converter Chain

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ABSTRACT

A 141GHz source is realized using a resistive up-converter driven by a single GaAs Gunn oscillator delivering fundamental (47GHz) as well as 2nd harmonic (94GHz) frequency power. The output power at the sum frequency is 3dBm.

Introduction

In the past few years low noise local oscillators up to about 110 GHz have been built as second harmonic oscillators /e.g. 1,2/ using GaAs Gunn diodes. In these oscillators the fundamental wave is generated in such a way that it has a high harmonic content. Only the second harmonic wave is coupled out. It has been found that third harmonic generation (especially in the 140GHz range) is not efficient due to the drop of the high-order harmonic power and the increasing influence of the parasitic elements of the Gunn diode housing.

In this paper a resisitive up-converter will be described, which combines the fundamental with the second harmonic output of a 47GHz GaAs Gunn oscillator to produce 141GHz as the sum frequency.

Principle of Operation

The basic idea of this type of 141GHz source is the double use of a Gunn oscillator as a fundamental and 2nd harmonic generator simultaneousely. Both frequencies, 47GHz and 94GHz, are given to a mixer diode.

This option was chosen because the large-signal conversion loss of a resistive up-converter theoretically is lower than in a resistive tripler-circuit at the same saturation level and the same output frequency /3,4/.

For this case the theoretical limits differ by 3.5dB in idealized circuits.

Oscillator Design

Fig. 1 shows the set-up of the oscillator in principle. Similar to the previously described oscillator /5/, the length of the diode-mount is made approximately $\lambda_{gf_o}/2$.

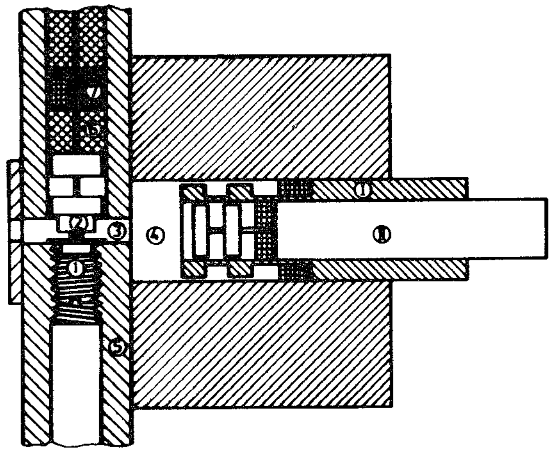

Fig.1 Set-Up of the Gunn-Oscillator

1 Gunn-Diode
2 Radial Line Transformer
3 Rectangular Waveguide
4 Circular Waveguide
5 Diode-Mount
6 Teflonsupport
7 Absorberring
I Backshort for f_o
II Backshort for $2f_o$

By connecting a backshort-loaded circular waveguide to one side and a W-band spacer to the other, a resonant cavity for both frequencies f_o and $2f_o$ is formed. The rectangular waveguide of the diode-mount has the same cut-off wavelength as the circularwaveguide. For optimum operation the condition $\lambda_{gf_o} = 3\lambda_{g2f_o}$ must be fulfilled /5/, giving a cut-off wavelength of $\lambda_c = 1.265\,\lambda_{f_o}$

The frequency of oscillation, f_o, is determined only by the backshort (I). This backshort contains another concentrically arranged backshort (II) for $2f_o$. The latter is taken to match the output power at $2f_o$ to the up-converter. Gunn diode prematching at $2f_o$ is accomplished by a quarterwave radial line transformer /6/ giving a high transformation ratio. A "94GHz" Gunn diode made by Thomson CSF and 12dBm at 94GHz.

Up-Converter Design

Fig. 2 shows the set-up of the up-converter.

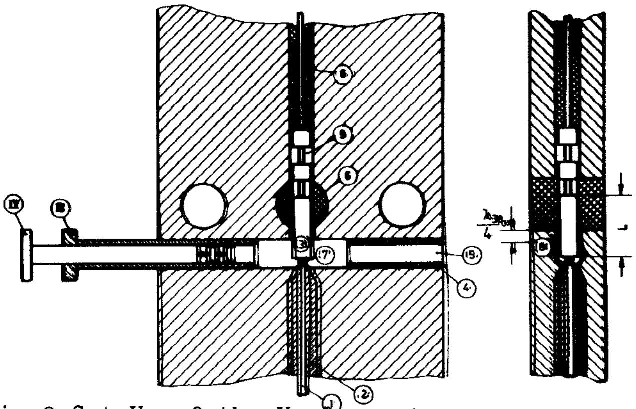

Fig.2 Set-Up of the Up-Converter

1 Diode-Pin	6 Teflonsupport
2 Collet	7 Mixer Diode
3 Bias Pin	III Backshort for $2f_o$
4 Cut-Off Filter	IV Backshort for $3f_o$
5 Output Port	

Input port is a circular waveguide (6) which transmits both frequencies f_o and $2f_o$. The output waveguide (5) houses the mixer diode (7) (MDX 683 made by Texas Instruments) and is arranged perpendicularly to the input waveguide in a distance of $\lambda_{3f_o}/4$.
Both input frequencies are coupled to the mixer diode via the bias pin (3). The length L of the coupling section is chosen in such a way that in connection with the diode a series resonator for the fundamental frequency is formed. The second harmonic wave is matched to the diode using a 94GHz backshort (III).
The mixer diode is matched at the sum frequency by another backshort (IV) which is concentrically arranged in backshort (III).
A cut-off filter is used to stop the 2nd harmonic frequency in the T-band output waveguide.

The complete arrangement

Fig. 3 shows the complete arrangement of the oscillator and up-converter mount.

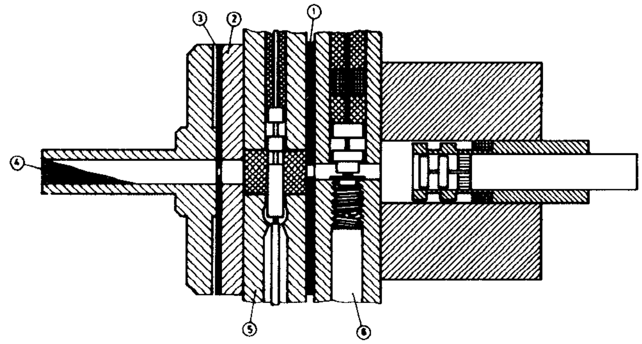

Fig.3 141GHz-Oscillator-Up-Converter Chain

1 W-Band-Spacer	4 Absorber
2 V-Band-Spacer	5 Up-Converter-Mount
3 Resonant-Iris for f_o= 47GHz	6 1st and 2nd Harmonic Oscillator

To prevent total saturation of the mixer diode by the rather high oscillator power at fundamental frequency, only 10% of the power is coupled to the diode. The rest passes the up-converter and is absorbed in a matched load (4). One additionally desired effect of this measure is that load pulling caused by up-converter adjustment is reduced. A resonant iris (3) is used to prevent loss of 2nd harmonic power this load.

Results

The oscillator power has been measured as 21dBm at f_o=47GHz and 12dBm in the up-converter mode (both f_o and $2f_o$ incident to the mixer diode) and was measured as 0dBm in the tripler mode (only f_o incident to the mixer diode). This result corresponds very closely to the predictions of Page /3/ and Pantell /4/ concerning the conversion efficiencies of mixers and multipliers built with ideal rectifiers.
In Fig. 4 the spectrum of the 141GHz up-converter source is shown. The spectrum was measured using a low-noise 140GHz mixer pumped by the source described here.
Signal source was a third harmonic oscillator (140GHz, Gunn diode made by Thomson CSF).
In these measurements a carrier-to-noise ratio (at 1MHz off carrier) of at least 113dBc/Hz were found.

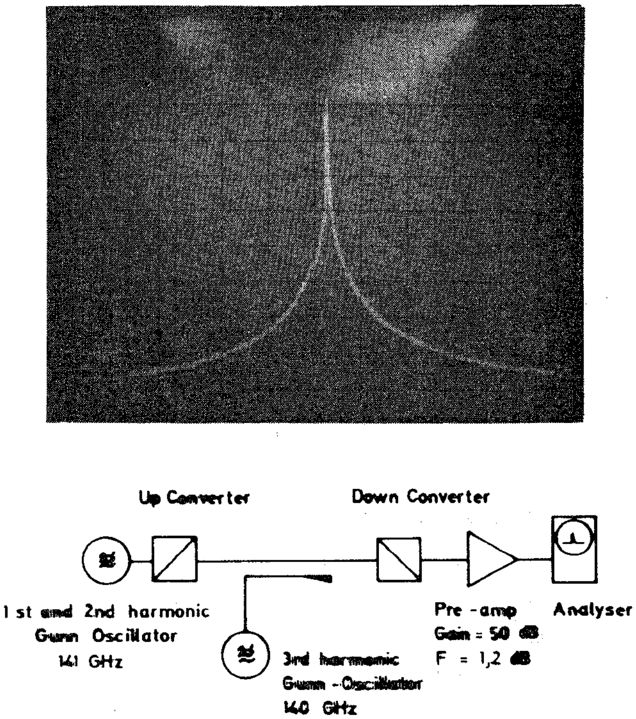

Fig.4 Spectrum of the 141GHz-Source and Test Set Up

Analyser Setting:	IF-Bandwidth	100KHz
	Scan-Width	1MHz/div
	Vert.Res.	10dB/div

In an additional experiment the influence of the oscillator noise to the 140GHz mixer was tested. The IF noise power was measured by means of an IF preamplifier (Gain = 50dB, NF = 1.2dB) and a spectrum analyzer. The up-converter, working as LO was switched on and off and no variation of the IF noise power was detected with this test set-up. The bias current of the mixer diode was kept constant at 500 μA.

Acknowledgement

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