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The Oscillator Circuit Based on Resonant Tunneling Diodes

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Abstract:-The resonant tunneling diode (RTD) has been applied to some kinds of microsensors and actuators .These sensors are based on the RTD with a frequency output. The oscillate circuit based on the RTD is the more importance factor on sensitivities and stability of the sensors .In this paper , two kinds of oscillator circuit are introduced, the principle function of the oscillator circuit is explained. The necessary conditions on operating of the oscillate circuit are advanced. The conditions are testified accurate by the experiments .The experimental results show the conditions affect the sensitivities and stability of the sensors.

Key-Words: -oscillator circuit, necessary condition, frequency output, resonant tunneling diode, GaAs

1 Introduction

The resonant-tunneling diodes (RTD) which use the electron were reasonable in multibarrier heterostructures appeared as a pioneering quantum, device in the mid 1970s. The idea of resonant tunneling in finite semiconductor superlattices was first, proposed by Tsu and Esaki in 1973.A unique phenomenon of electron tunneling based on electron-ware reasonable, was predicted for an AlGaAs/GaAs/AlGaAs double-barrier heterostructure in which the bias dependence of the tunneling current through the structure results in negative difference resistance (NDR). [3]-[4].The widely study of the last three decades on resonant tunneling diode (RTD's) has been applied to some kinds of microsensor and actuators, such as pressure sensor, acoustics sensor, acceleration sensor and so on..

A GaAs pressure sensor and a GaAs acoustical sensor with frequency output based on resonant tunneling diodes have been investigated. The principal of these sensors is that pressure applied to the RTD relative change of the RTD voltage or current in dependence of the strain changes the frequency of oscillation due to the shift in current-voltage characteristics. Sensitive and stability of the ones are mostly relative to the oscillator circuit. [1]-[5]

In this paper, necessary conditions of oscillating of the oscillator circuit and stability including the RTD are studied. They insure the oscillation of the circuit.

2 The oscillator circuit and the principle function

A relaxation oscillator produces a square-wave like wave form. The oscillator consists of a voltage supply, a serial inductor, a RDT, and a capacitor Fig.1[3]. The oscillations are due to the dc instabilities caused by the RDT when base inductance value, the shape of the RTD current-voltage characteristic and the bias voltage. The capacitances determine the rising and the falling times of the oscillator voltage edges. There fore the influence of the capacitance on the frequency is minor as compared to the inductance.

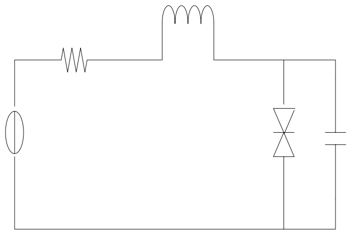

Fig1. Schematic of the RTD oscillator circuit

The principal function of the oscillator can be intuitively explained Fig.2Fig3. First, the current rises until it reaches the peak value A; second, the serial inductance, the parallel capacitor and the NDR force the diode to switch from to B. the inductance maintains the currant while the capacitor takes up the difference current and therefore increase the RTD voltage. Switching from B to C occurs rapidly. Thirdly, the voltage reached is above the bias point and cannot be maintained by the voltage source. Therefore the voltage decreases with a time constant determined by in the inductor and the nonlinear RTD positive resistance. Lastly, if the volley voltage (point C) is reached, a fast transition to point D takes place. The diode current increases while the inductor current remains constant. The current difference is supplied by the capacitor. [1]

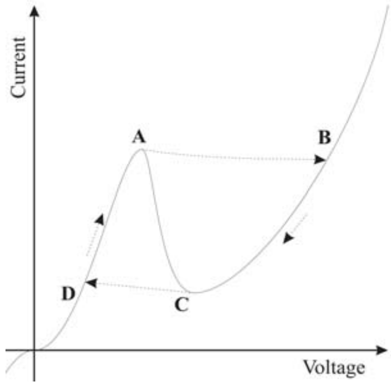

Fig2.Typical RTD current-voltage characteristic; the arrows indicate the I-V excursion of the RTD during an oscillation cycle.

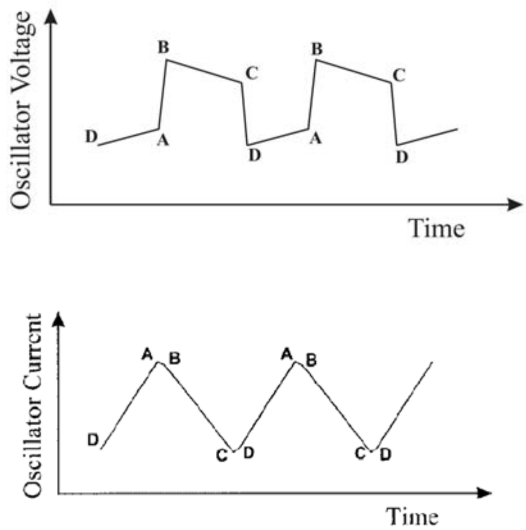

Fig3. Oscillator current waveforms

The other oscillation circuit consists of an RTD, a high-electron-mobility transistor (HEMT), and inductor, is shown in Fig.4.[10]. The oscillating occurs for a slight increase in Vb. The oscillation frequency of this circuit is determined by the RTD switching time and

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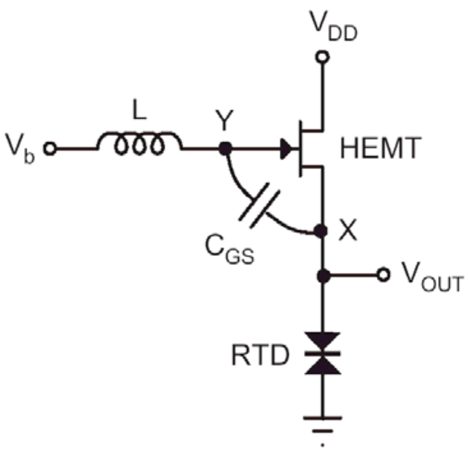
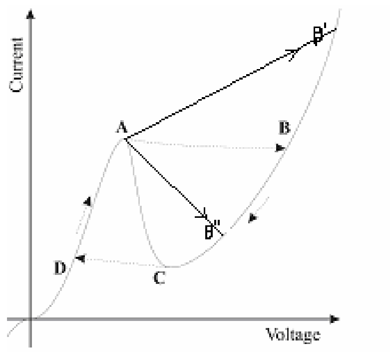


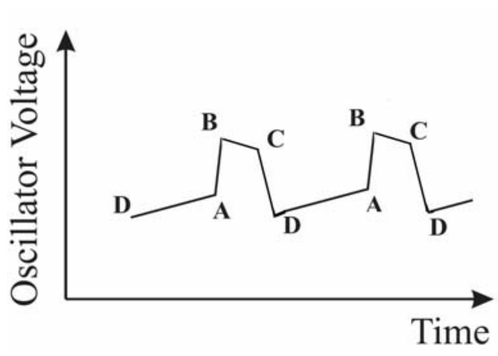
Fig.4. RTD oscillation circuit

the charge/discharge LC time constant. The circuit exhibits a forced oscillation .the oscillation frequency increases by increasing the RTD peak current density.[10] By comparing the two kinds of oscillation circuits ,the first one is more suited to the sensors .In this paper, the first circuit is discussed.

3 The necessary conditions

The oscillator circuit consists of a voltage supply, a serial inductor, a RTD and a capacitor. The characteristics of the RTD remain fixedness. In the oscillator circuit, the main factors determinedly the oscillating are the voltage supply, the capacitor. and the series resistance. First, the voltage supply must vary between the peak voltage and the valley voltage. When the voltage supply approaches the peak voltage or the valley voltage, the oscillation frequency decreases to zero. Therefore the highest sensitivity is reached as the voltage close to the peak voltage or the volley voltage. [1] Second, if the series resistance is smaller than the absolute value of the negative differential resistance, the circuit will oscillate when the diode is biased in the negative differential resistance region. If the series resistance is larger than the absolute value of the negative differential resistance of the diode, the circuit will function as a switch. [2][7][8]. The parallel capacitor is moderate, if it is over small, the bias voltage becomes far higher than the point B so as to the RTD are destroyed during switch from B to C. [7]-[9] If it is over big, the waveforms are changed, even if the oscillation can not occur. The serial inductance must be a nice match for the capacitor according to the oscillator circuit. The inductance determines the time from B to C so that affect the waveform. Fig.5. The exact value of the capacitor and the inductance can be calculated out.





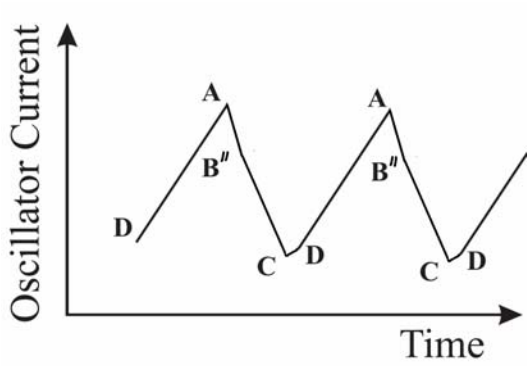
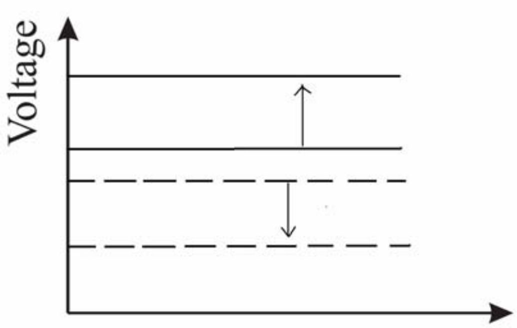


Fig5. Oscillator current waveforms on a mismatch capacitor and a mismatch inductance

4 Experimental result

When the supply voltage is higher than the valley voltage, the oscillating cannot occur, while the voltage occur step response. Fig.6 The series resistance is larger than the absolute value of the negative differential resistance of the diode. The result is the same. When the bias voltage is adjusted b, the bias voltage rapidly steps to a, and the bias voltage is adjusted c, the one rapidly steps to d. When the capacitance is over small, the bias voltage becomes over high by the varying of the current though the capacitor, so the RTD is wrecked.

When the above conditions are satisfied, the oscillation takes place. Fig.7 shows the output frequency and waveform of RTD.



Frequence

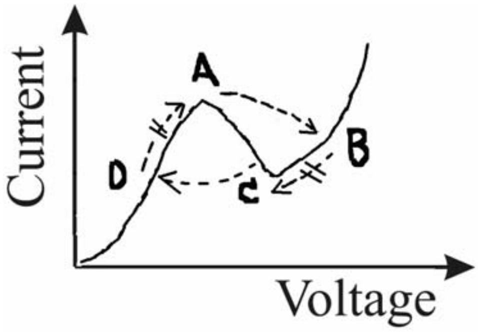


Fig6. Results on dissatisfy conditions

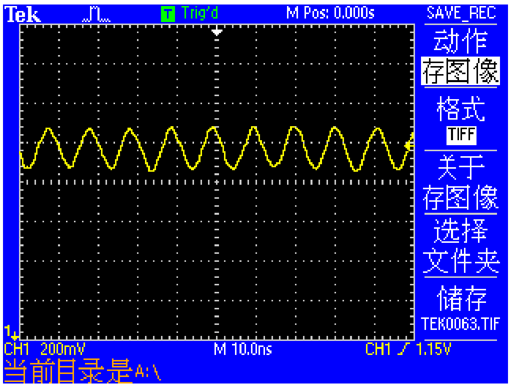


Fig7.Output waveform of RTD

5 Conclusion

The assumptive necessary conditions are confirmed. The stable output frequency depends on the voltage supply. The waveform is determined by the capacitor .The serial inductor determines the frequency. Under high frequency, the capacitor and the parasitical inductor affects the RTD length of life .When the circuit stably operates, the sensitivities of the sensor can be defined by simple changing the bias point of the RTD in the negative resistance region.

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