STUDY OF DISTRIBUTED SYSTEM AMPLIFIERS AND OSCILLATORS USING NEGATIVE RESISTANCE IN SEMI-CONDUCTORS

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«صدق الله العظيم»

بسم الله الرحمن الرحيم

Study of Distributed System Amplifiers and Oscillators using Negative Resistance in Semi-conductors

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ABSTRACT

The aim of the present work, is to study the propagation of electric signals through active distributed systems (amplifiers and Oscillators) using tunnel diodes. Experimental and theoretical investigations of the tunnel diode cascaded amplifiers and oscillators were carried out using Ga As tunnel diodes. The fundamental results of the thesis are:

A. Theoretical analysis of the distributed amplifier using distributed equivalent circuit, and three different approachs shows that, the attenuation constant of the line $|\alpha|$ and the imaginary part $|\beta|$ (phase shift) increase sharply with the frequency $n=w/w^*$ in the low frequency range $0<n<1$, then decrease at higher frequencies ($n>1$). Until $|\alpha|$ becomes nearly of negligible value at $n=10$, and $|\beta|$ becomes in the order of 0.1. . Moreover, the calculated characteristic wave impedance of the transmission line increases linearly with the frequency $n=w/w^*$, ($w^* = 1/CR_o$).

B. Experimental design of the distributed tunnel diode amplifier (in the range of frequencies from 1 to 10 MHZ) shows that, the gain of the cascaded amplifier

exceeds unity. It decreases somewhat after three cascaded stages if the tunnel diodes used are all of the same type. The gain has a value of 2.6 at f_o=1.7 MHz for three cascaded stages with T.D.of the type AИ301БX. The dependence of the gain of the individual stages and the cascaded stages, on the frequency was measured using an input signal amplitude of 20 m V , and it shows that, in general the gain increases with the frequency, reaching a peak value then it decreases at higher frequencies. For the cascaded stages amplifier the gain has at least two peaks at two different frequencies one of the peaks has a higher value. It is found that, the peak gain depends on the following factors:

The type of tunnel diode,

The working bias voltage,

The values of the circuit parameters (L, C , R_L and r_o).

The number of T.D. used in each stage,

The number of cascaded stages, and

The type of cascading circuit connections.

In general, the shape of the gain-frequency dependence is attributed to the dependence of the negative resistance of the T.D. on the frequency and to the resonance nature of the circuit (L,C).

The amplitude characteristics of the individual stages and the cascaded stages measured at the frequency of the peak gain were found to be almost linear.

It is found that, the optimum circuit parameters for a peak gain are:

$R_L = 10\ k\Omega$, $r_o = 1\ \Omega$, $L = 25\ \mu H$, $C = 10^3$ pF and $R = 3\ \Omega$.

Moreover, it is found that, the gain is greater when the series diode (TD1) is shunted with a small resistor $r_o = 1\ \Omega$.

C. Theoretical analysis of the distributed oscillator using distributed equivalent circuit shows that, the frequency of oscillations $n=w/w^*$ decreases with increasing m values; ($m = r_o/R_o$) i.e. with decreasing the negative resistance of the tunnel diode (R_o); while it has a constant value for all values of S, ($S = L/C_d R_o^2$) i.e. for small distributed capacitance (C_d) and high negative resistance values.

D. Experimental study of the individual tunnel diode oscillators shows that; the amplitude, frequency as well as the form of the out put oscillations depend on the following factors:

The bias voltage u_o,

The circuit parameter values (R_L, r_o), and the values and positions of external variable air capacitor (C1)

The dependence of the amplitude and frequency of oscillations on the bias voltage (u_o), and the external capacitor (C1), were measured for the individual I.D oscillators. It shows that, the frequency of oscillations increases with the bias voltage reaching a peak value, then decreases at higher bias values.

While, the amplitude of oscillations increases somewhat with the bias voltage. Both the frequency and amplitude drop to zero at certain bias voltages, which reflects the limits of the dynamic negative resistance of the tunnel diode.

The dependence of the frequency of oscillations on the external variable capacitor C1 (50-875 PF) in three positions I, II and III, shows that, it decreases with higher values of C 1, for positions II and III, while for position I it is almost constant with increasing C 1. The dependence of the amplitude of oscillations on C 1 shows that, it increases slightly with the values of C 1 for all the three positions (I, II and III).

Out put wave forms confirm the dependence of the amplitude and frequency of oscillations on the bias voltage and the position of C 1.

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CHAPTER I

INTRODUCTION