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SIMULATION OF (R,L and VARACTOR DIODE) SERIES CIRCUIT USING ELECTRONICS WORKBENCH

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Abstract:

The behavior of nonlinear resonator(R,L and Varactor diode) series circuit are simulated in this paper using Electronics workbench program version 5.12 for two diodes (BYW32 and BYW36).Unstable behavior was observed during the range of frequency (F = $1.5X10^4$ – 2X 10^5Hz) which the circuit behave randomly. It is not possible to measure V_R,V_L,V_D and I exactly**.**

Introduction:

The nonlinear dynamics of the p-n junction has been a subject of intense interest since the dawn of chaos [1,2] and experimental work has focused on the damped driven nonlinear oscillator formed by a resistor ,inductor and varactor diode (RLD circuit) connected in series [3]. The optical bistable device has been shown to exhibit period doublings and choose [4] .

Simplest passive circuit that displays period doubling and chaos is a good model of the ubiquitous p-n junction and its nonlinear resonator[5]. From the particular point of view these experiments are much simpler for the study of the universal behavior of all the nonlinear dynamical systems[6], while chaotic behavior was also reported for the response of a driven oscillator [7].Variable capacitance diode can be used in any tuned circuit application where previously mechanical methods where utilized, and provide a size ,cost and performance advantage[8] . And used as in FM tuning ,Fiber–optics receiver[9] and antenna[10] application.

VARACTOR DIODE:

A varactor diode changes capacitance proportional to the reverse bias across the p-n junction. Two common types of varactor diodes; abrupt and hyperabrupt. The abrupt junction varactor diode is made with a linearly doped p-n junction and typically has a capacitance that changes the specified range of reverse bias. Abrupt junction diodes are available with maximum reverse bias voltage between 5V and7V.A Hyperabrupt junction varactor diode has a nonlinear doped p-n junction that increases the capacitance changes vs. reverse bias.[11]

SIMULATION RESULTS:

Resonator used in this study comprised of two diode type (BYW32 and BYW36), an inductor of (2mH) in inductance and a resistor of variable resistance, and a signal generator type (10-$3X10^5$Hz)as shown in figure(1). It generate Sine wave (0-15)volt. Current in the circuit and voltage drops at each element were recorded using a electronics workbench program.Pervious studies [12,13] investigated the voltage signal on the resistor R,the inductor L and the capacitor(the varactor)C of diode type 1N4007.

To get an overview of the whole chaotic behavior of the resonator in this study with the aid of driven nonlinear oscillator ,the relation of V_R(voltage at resistor),V_L(voltage at inductor),V_C(voltage at capacitor) and current I, in this circuit ,against the frequency were studied .Applied voltage, resistor and inductor were(Vin = 15 volt ,R=200Ω and L =2mH) respectively, and diode types were (BYW32 and BYW36) as a figure (1) .

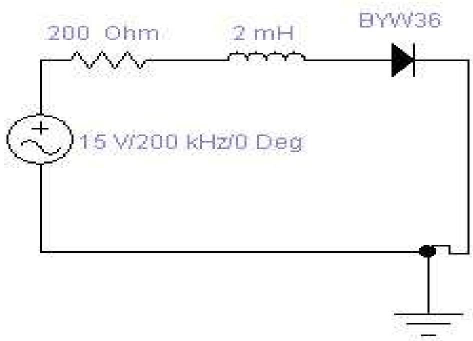
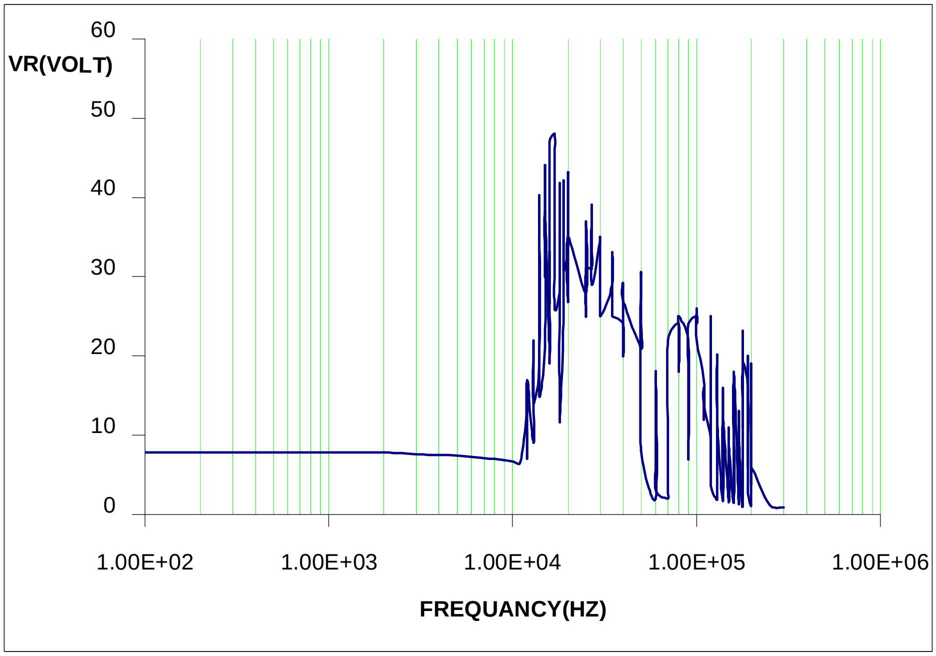


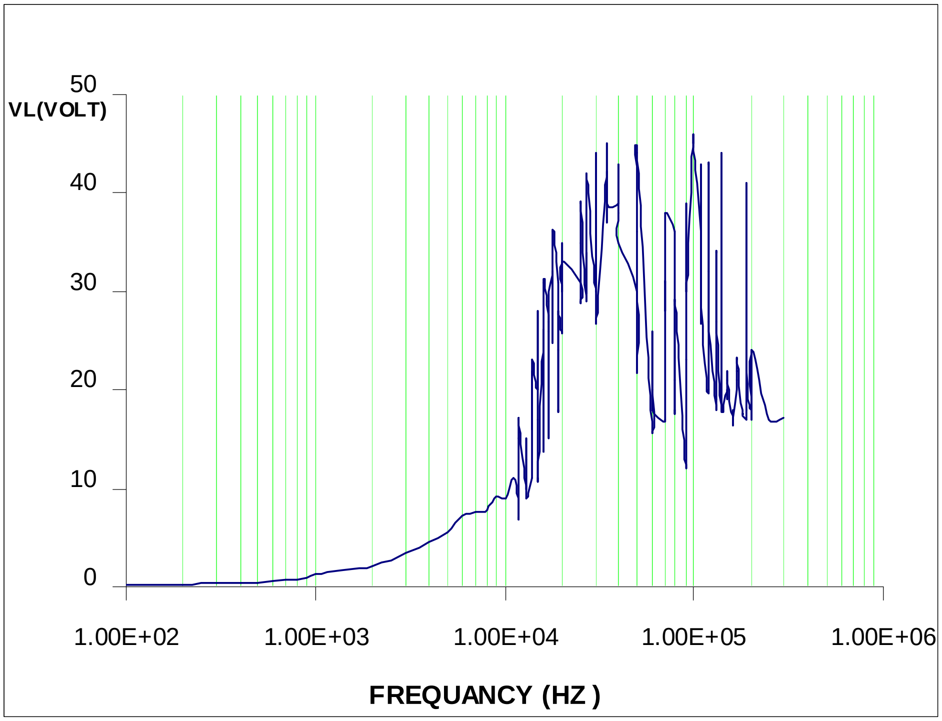
Figure (1). Equivalent diode circuit

The study of simple nonlinear electrical resonators proved to be as important as other types of resonators[14].

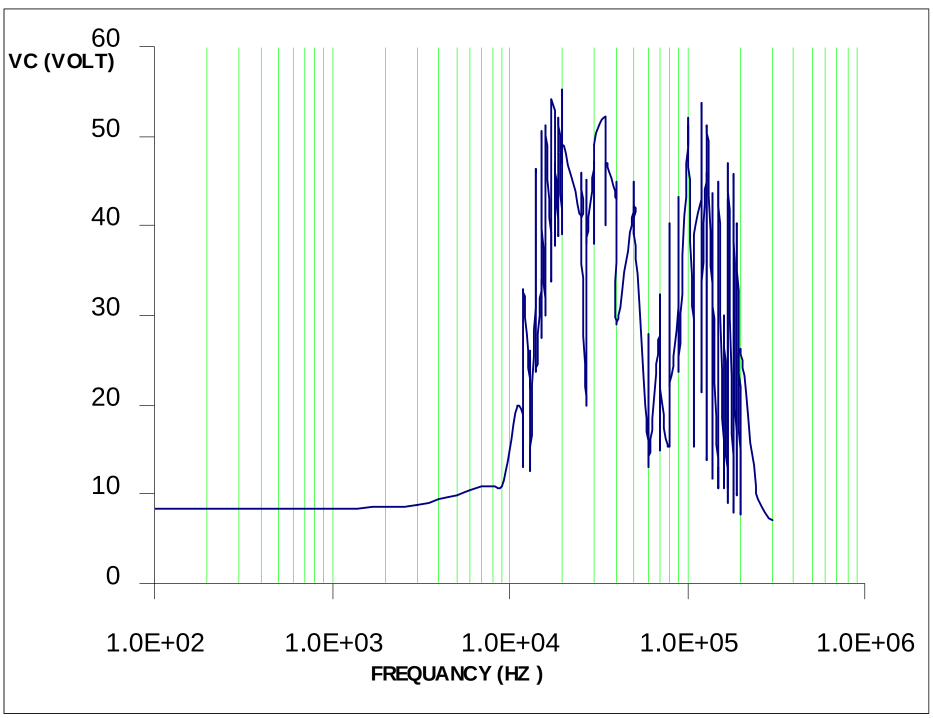
Figures (2 to 5) represented the relation of each of V_R,V_L,V_D and I against frequency F respectively, for varactor diode type BYW32.Figures (6 to 9) represented the same relation of V_R,V_L,V_D and I against frequency F respectively for varactor diode type BYW36. Figures (10–12) shows the signal behavior at each element with increasing frequency at each of V_R,V_L,V_D respectively with time for different frequencies for the above two diodes. Figure (13)shows the difference between V_{IN} and V_{OUT} when we added resistance (1kΩ) in series between varactor diode and ground, when F = 100kHz it is obvious that the V_{IN} sine wave and V_{OUT} are square waves and they are to be applied in a signal generator.



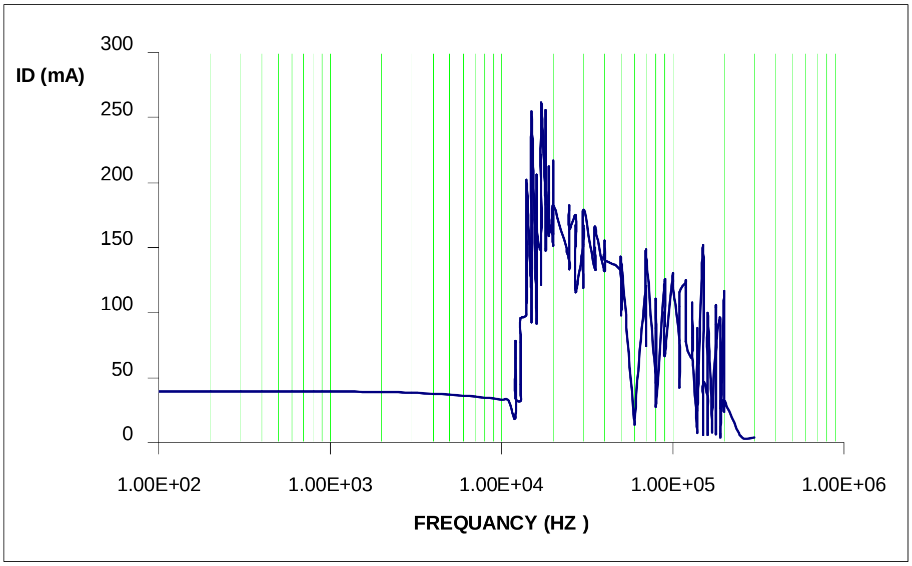
FIG(2) Relation of voltage difference on the resistor V_R and frequency when (R = 200Ω, L = 3mH and Vin =15 volt) for diode type(BYW32)



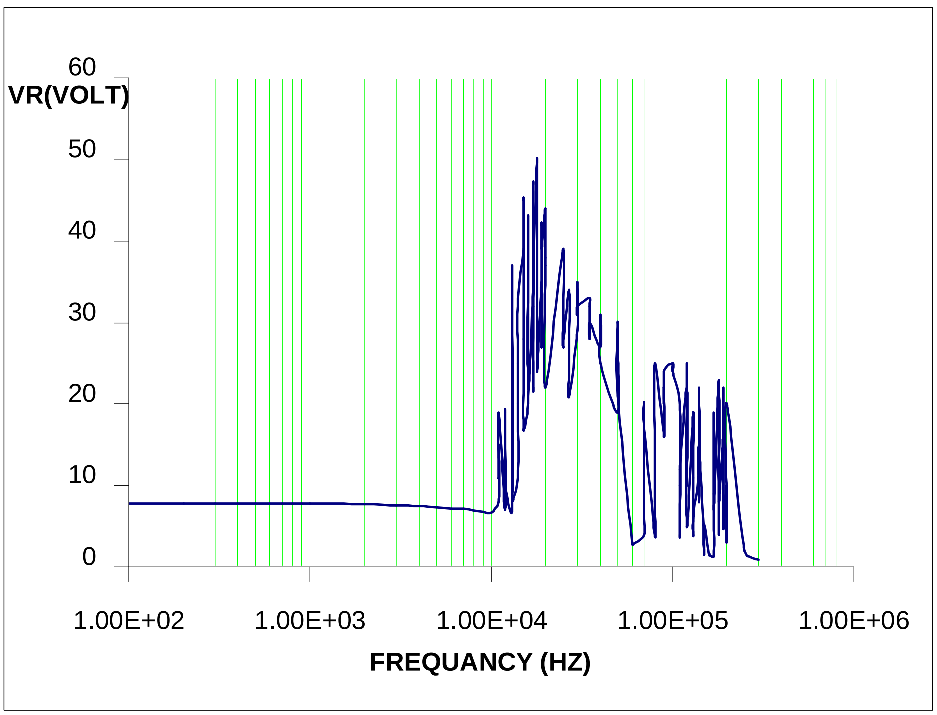
FIG(3). Relation of voltage difference on the inductor V_L and frequency when (R = 200Ω, L = 3mH and Vin =15 volt) for diode type(BYW32)



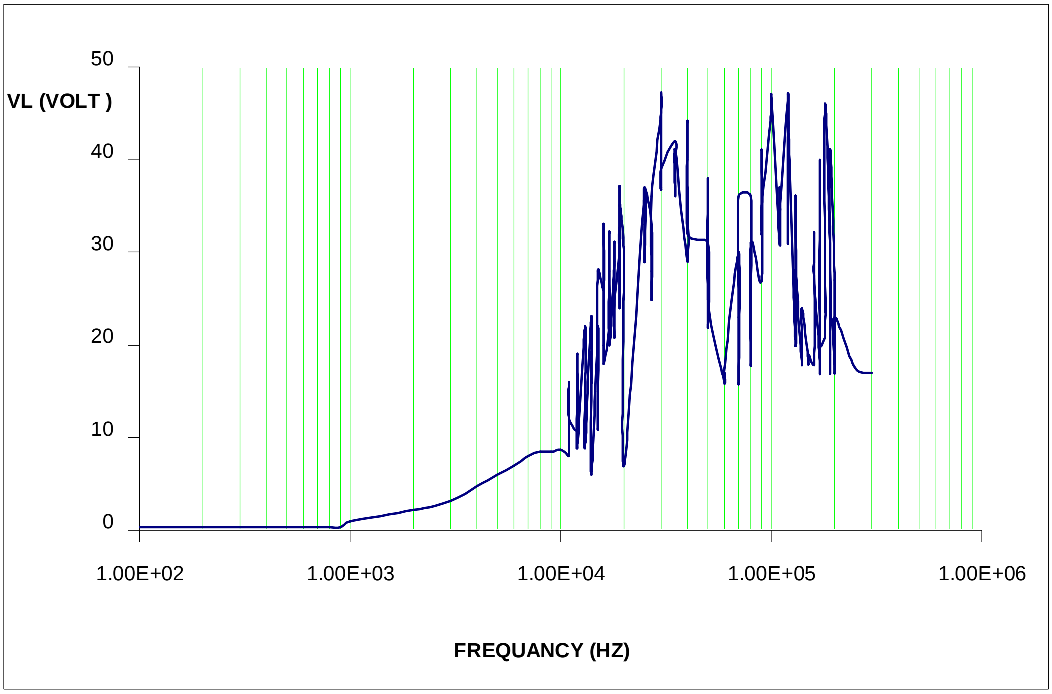
FIG(4). Relation of voltage difference on the capacitor V_C and frequency when (R = 200Ω, L = 3mH and Vin =15 volt for diode type(BYW32))



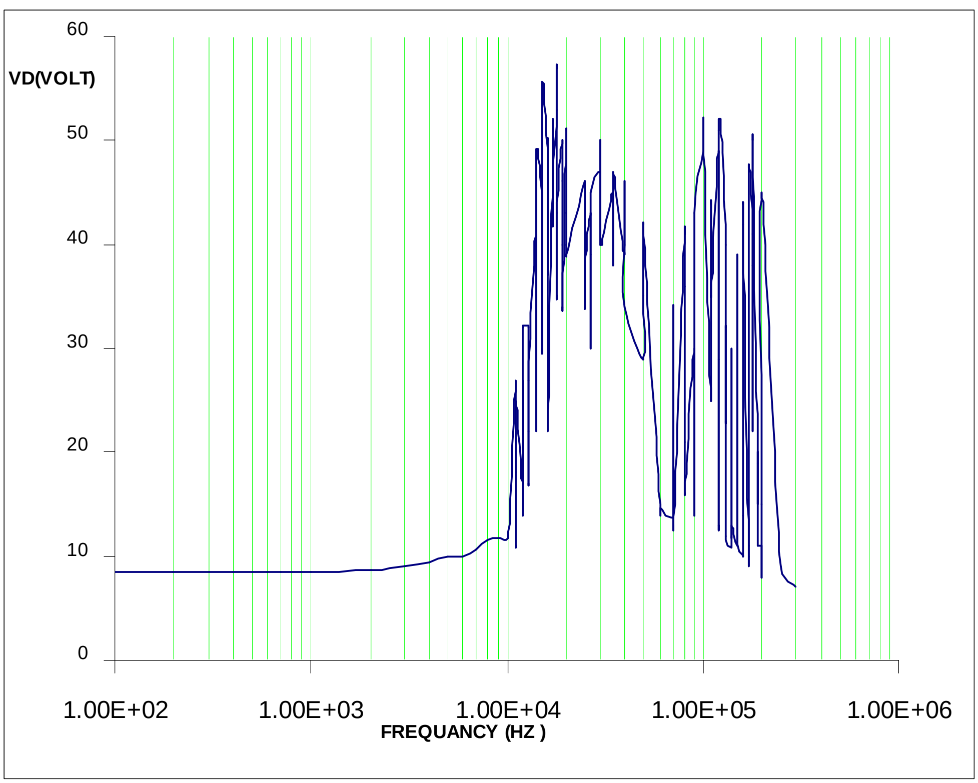
FIG(5) Relation of current and frequency when (R = 200Ω, L = 3mH and Vin =15 volt) for diode type(BYW32)



FIG(6) Relation of voltage difference on the resistor V_R and frequency when (R = 200Ω, L = 3mH and Vin =15 volt) for diode type(BYW36)



FIG(7). Relation of voltage difference on the inductor V_L and frequency when (R = 200Ω, L = 3mH and Vin =15 volt) for diode type(BYW36)



FIG(8). Relation of voltage difference on the capacitor V_C and frequency when (R = 200Ω, L = 3mH and Vin =15 volt for diode type(BYW36))

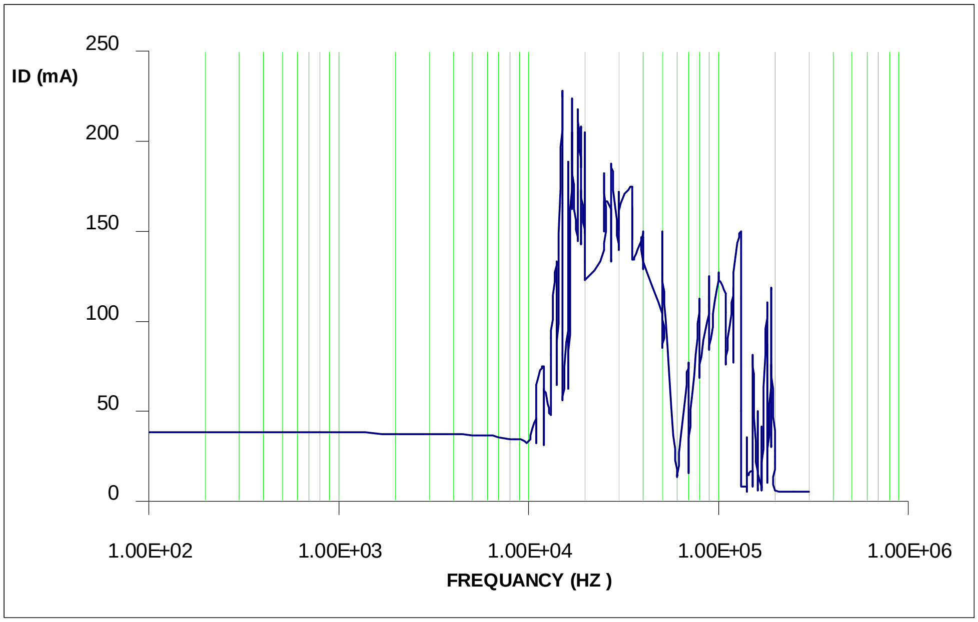
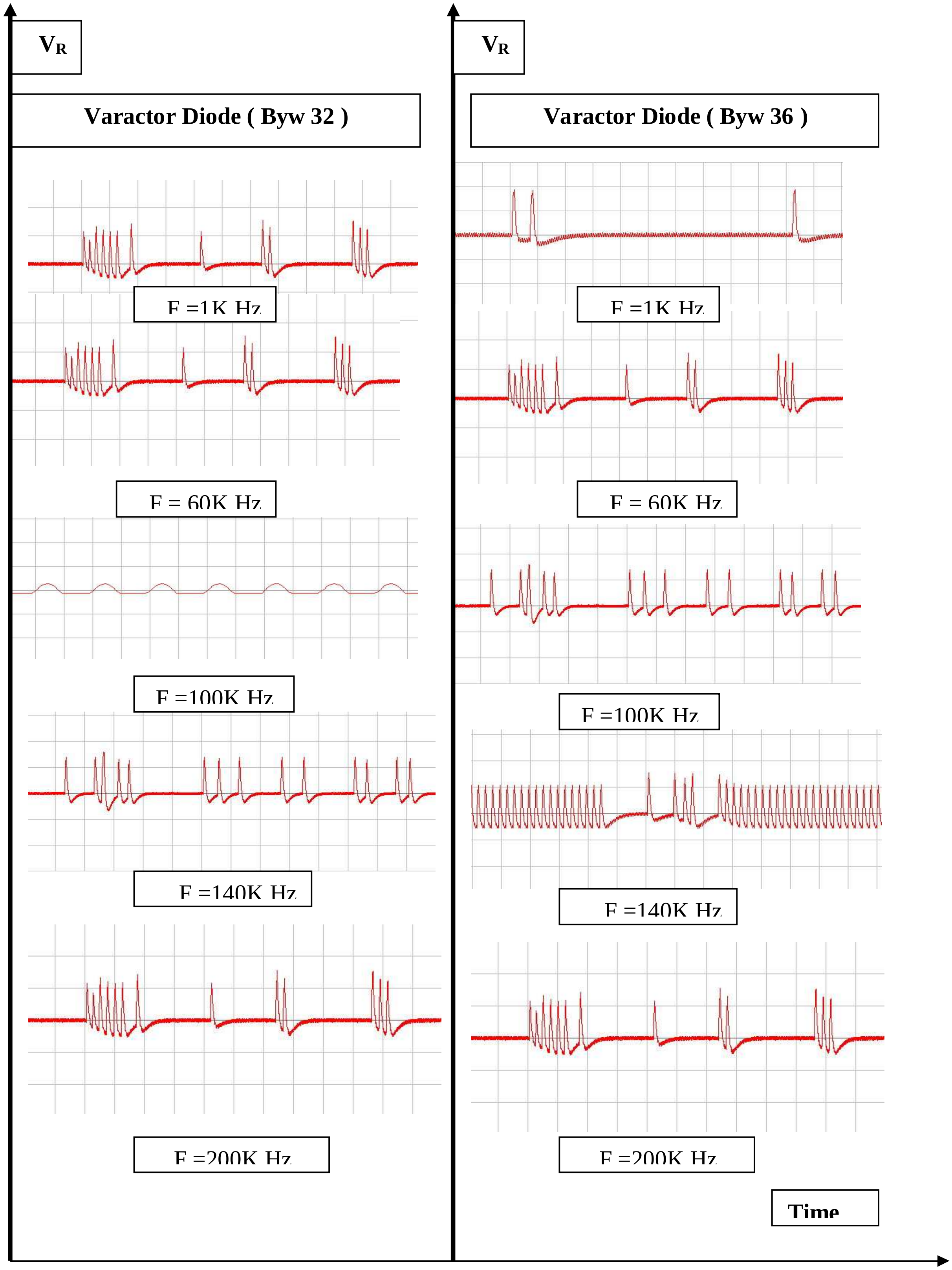
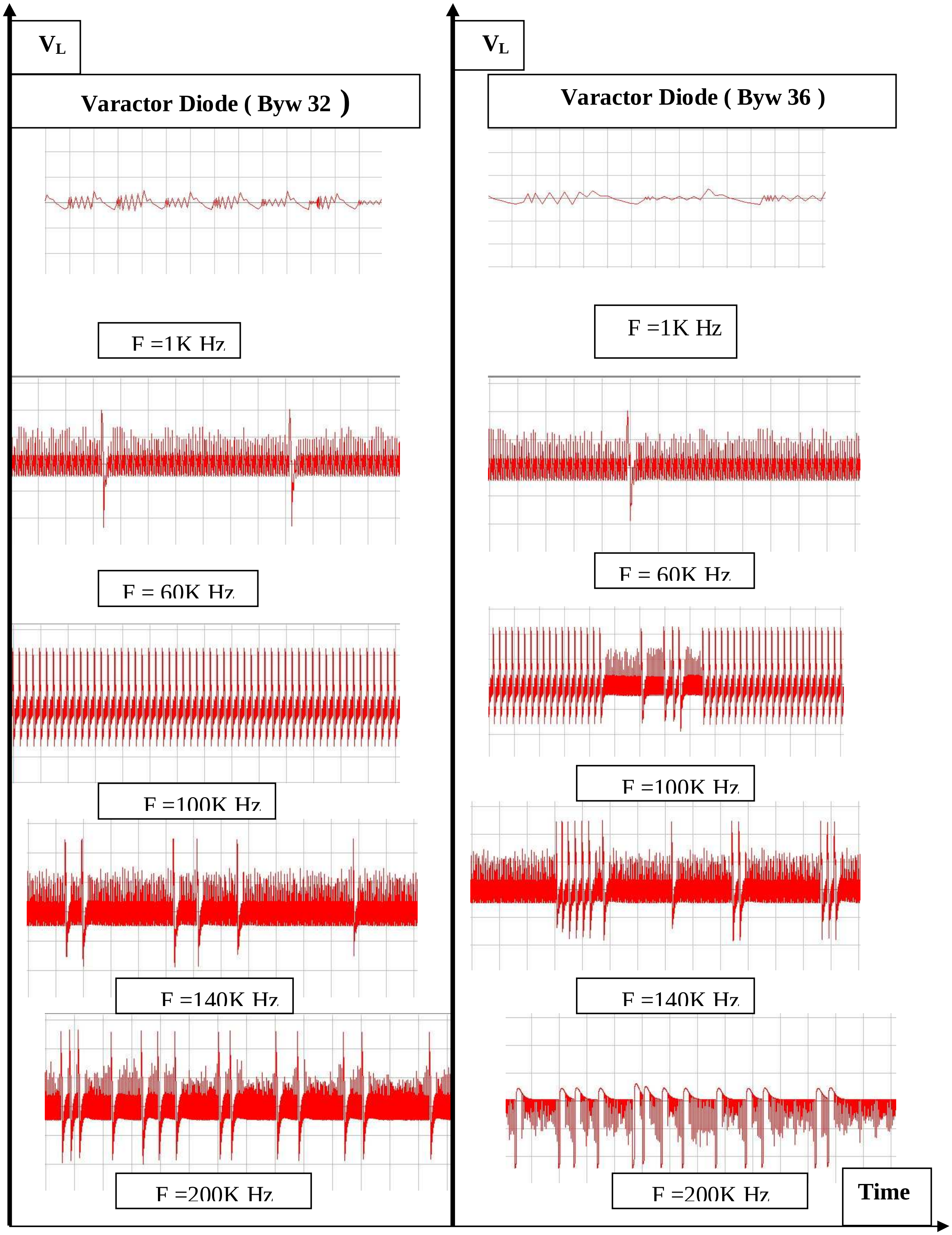


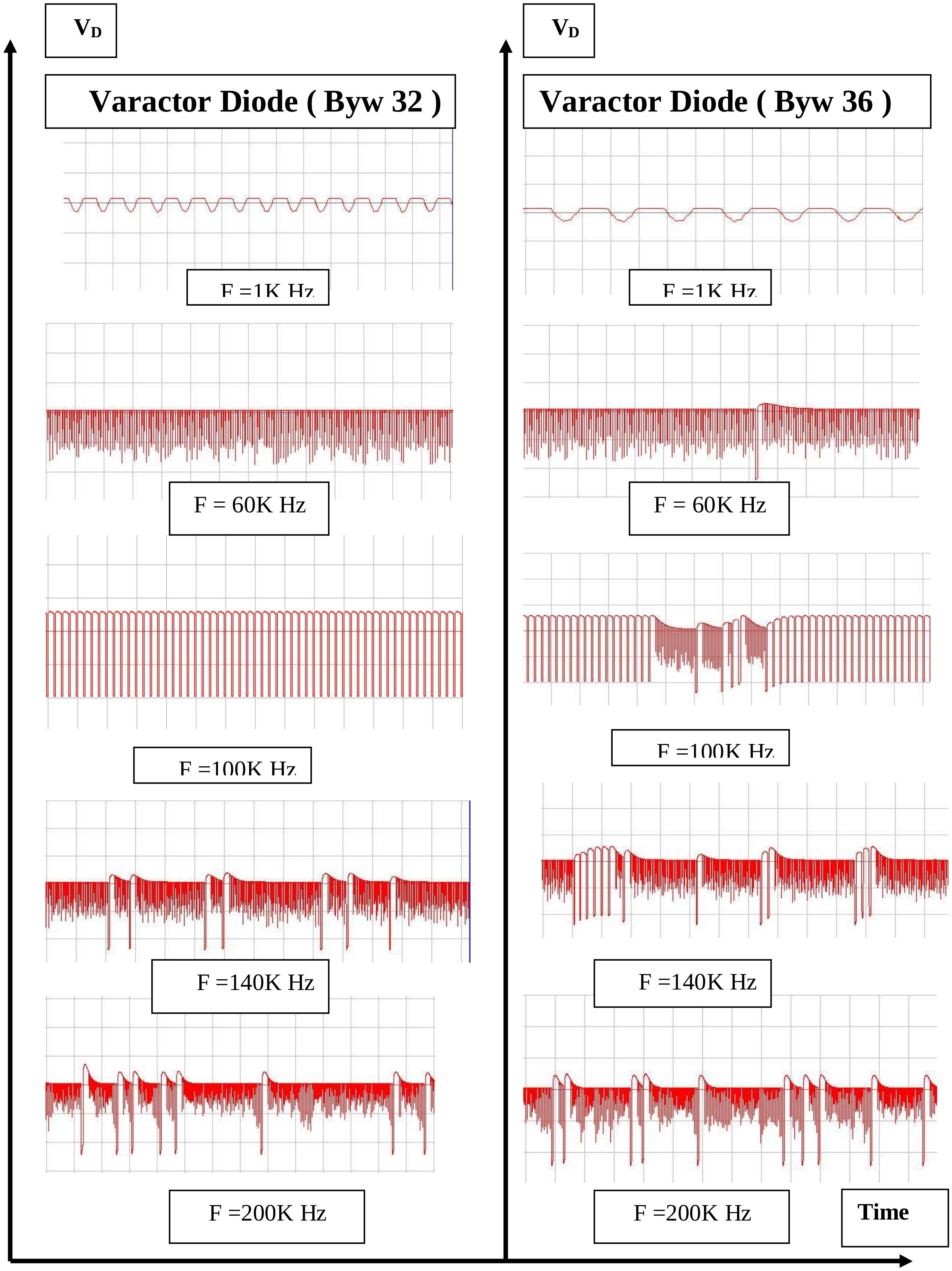
FIG (9). Relation of current and frequency when (R = 200Ω, L = 3mH and Vin =15 volt) for diode type(BYW36)



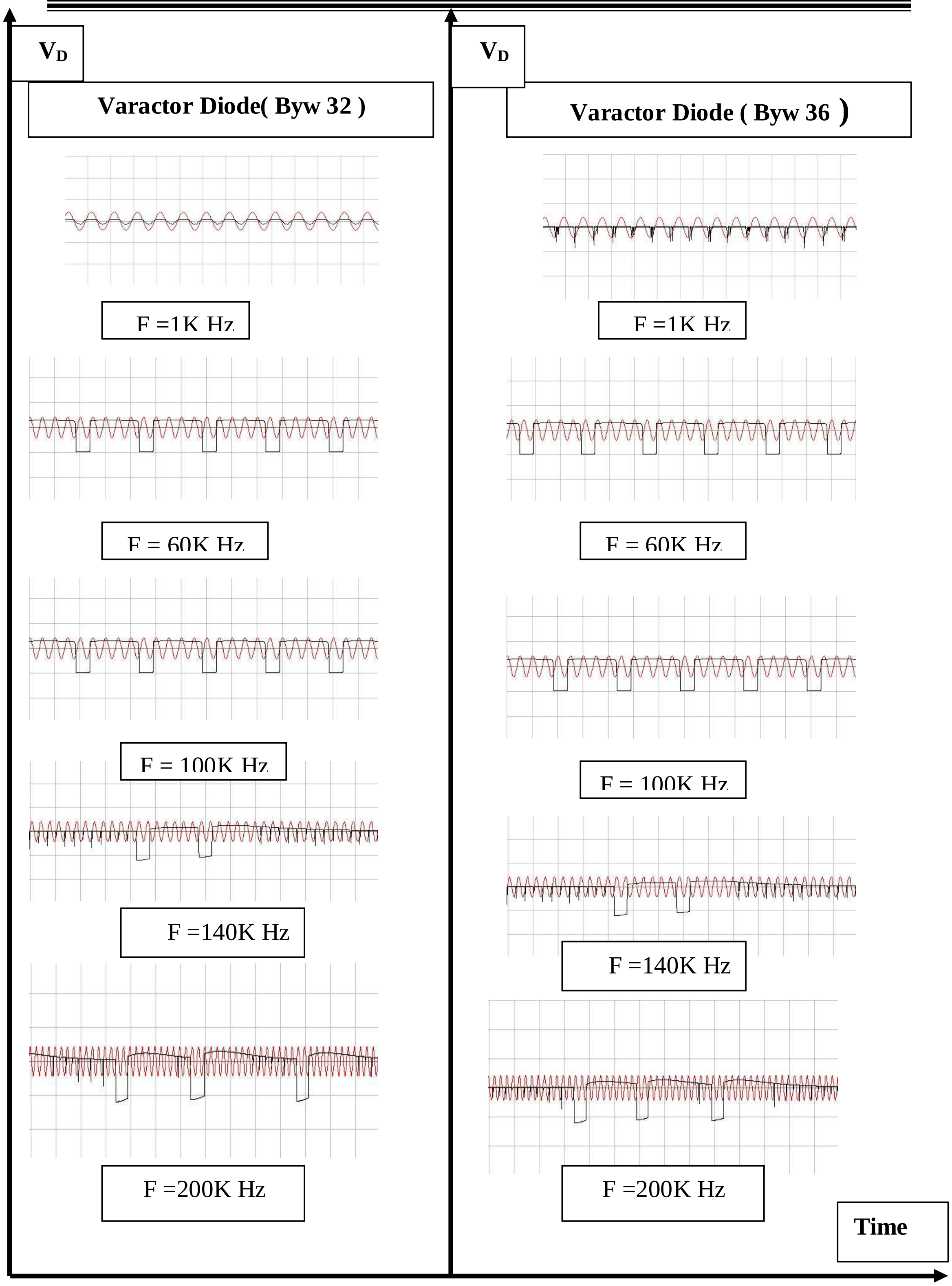
FIG(10) Relation of voltage difference on the resistor VR and Time when (F =1,60,100,140,200 KHz) for diode type(BYW32 and BYW36)



FIG(11). Relation of voltage difference on the inductor VL and Time when (F =1,60,100,140,200 KHz) for diode type(BYW32 and BYW36)



FIG(12). Relation of voltage difference on the capacitor V_C and Time when (F =1,60,100,140,200 KHz) for diode type (BYW32 and BYW36



FIG(13). Relation between V_{IN} voltage and V_{OUT} voltage when (F =1,60,100,140,200 KHz) for diode type (BYW32 and BYW36)

Results and Discussions:

If we assume no nonlinearity in this circuit, increasing input frequency will increase the inductive reactance $X_L= 2\pi fL$ and decrease capacitive one ($X_C = 1/2\pi fC$). This means that voltage will increase on L while it decreases on C until a situation will be reached where $V_L=V_C$ and current will be maximum where the impedance is given by:

$$Z= R \ (X_L=X_C) \qquad ----------(1)$$

From figures (2-5) one can draw the notice the following conclusions for diode type(BYW32) :

As F increased V_R almost constant until $F=1x10^4$Hz then the voltage reading shows instability when F increased more that $F=1X10^4$Hz, in other words, V_R varies continuously with time. Between $F=1.5x10^4$Hz and $F=2x10^5$Hz voltage reading is not stable completely .This is an indication of entering chaotic region .

In the inductor V_L, case as expected voltage increases as F increases up to $F=1x10^4$Hz then decreases when $F =2x10^5$Hz and it is not stable between $F =1.5x10^4$Hz to $F=2x10^5$Hz then decreases sharply with instability to almost zero voltage. This behavior cannot be explained using the standard electricity unless many kinds of nonlinearity exist in this circuit. The voltage V_D on the diode is almost constant until $F=1x10^4$Hz then it increases near $F=0.5x10^4$Hz .At $F=2x10^5$Hz it decreases sharply and loses instability when $F=2x10^5$Hz. A similar behavior for diode type (BYW36) was noticed for V_R,V_L,V_D and I in figures (6 to 9) respectively.

In the reverse direction ,the p-i-n diode ,like the varactor diode, varies in capacitance with applied voltage .The oscillator circuit has analogy with pendulum, often used as a demonstration of Faradays and Lenz's Laws.

Varactors are usually the Q factor limitation in RLC resonant circuit, where the varactor is the tunable element. A careful selection must be made to find the device with the highest Q for the frequency range of interest [11] .The quality factor Q is defined as the ratio of the resonant frequency to the bandwidth, so for the series circuit we have [15]

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The amplitude of the voltage across either the inductor or the capacitor at the resonant frequency is time the amplitude of the source voltage [16]. From eq.(2) the Q factor is unstable because C is unstable too, because the varactor diode is used with variable internal capacitor.

The property of varying the diode capacitance with the reverse voltage is useful in tuning circuit . The variation of capacitance with frequency depends on the semiconductor doping , because the concentration of electrons affect the capacitance depending on the doping, varactor diodes are classified as Abrupt Junction and Hyperabrupt Junction varactors.

The operating frequency of a coplanar patch antenna is tuned using a single varactor diode located at one of the radiating edges[10] .

Conclusions :

Using Electronics workbench program version 5.12 shows the following:

1. Nonlinearity in a simple(R,Land Varactor diode) series circuit for two types of varactor diode (BWY 32 and BWY36) between ($F =1\times 10^4 - 2\times10^5$ Hz) was noticed and this is caused by doping .
2. The existence of some kinds of nonlinearities response for such a behavior in depletion region of the diode .
3. Values for V_R , V_L ,V_D , and I and the range of voltage and frequency cannot be measured exactly.

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I would like to appreciate the kind initial suggestion of Prof.Dr. C.A.Emshary and his continuous and valuable support in this study.

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محاكاة لدائرة توالي(مقاومة،محث ودايود متغير السعة)باستخدام برنامج Electronics workbench

باسم عبداللطيف غالب

قسم الفيزياء الليزر/كلية العلوم للبنات/ جامعة بابل

الخلاصة:
محاكاة دائرة التوالي المتكونة من مقاومة ومحث ودايود متغير السعة نوع(BYW32 and BYW36) حيث ظهرت لنا تصرفات غير متوقعة أي لايمكن قياس كل من (V_R , V_L ,V_D , I) بصورة دقيقة وان الدائرة تكون غير مستقرة في مدى الترددات ($F=1X10^4$ – $1X10^5$ Hz).