Evaluation and Analysis of Nonlinear Bipolar Transistor Performance under High Temperature Using MATLAB

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Abstract

The Design and Analysis of Nonlinear Bipolar Transistor Performance Using MATLAB is present in this paper. The bipolar junction transistor (BJT) operation at non- linear circuit is representing a vital part in some application. Many BJT model has been introduced such as small signal, charge control and each model has its own area of application. The proposed model of nonlinear BJT based on circuit of R1 and R2 set the normal operation point and small signal gain is approximately set under ration R3/R4. A decoupling capacitor of 1uF has chosen to ignore the impedance at 1 KHz to generate frequency response. Novel development used for the characteristics mechanism replica and its performance representation of power transistor with enough memory effects is evaluated and examined. The electrical memory effects and thermal impact on the transistor presentation is compared. The results show important information about BJT performance and proper applications associated with each type under 45-90 ^{O}C.

Keywords- Nonlinear Bipolar Transistor, Performance, MATLAB

1. Introduction

Early 1948, the bipolar transistor was invented by Bell telephone laboratories USA. The BJT was the first mass introduce transistor by mean of MOSFET. Then, the introduction of metal oxide semiconductors in 1968s is improved and developed. The high density and minimum power of MOS techniques IS progressively worn the BJT. The behavioral expression of power transistor amplifier has original recollection effects of transistor knowledge based on its structures [1]. To describe the effects that vary on timescale is depend on the memory of amplifier a great deal longer than those related with RF interval [2]. A number of situation in memory effects of transistors are energetic identity heating due to the thermo dynamic consideration [3]. In some compound of semiconductor material systems, the parasitic bipolar transistor effect in SOI [4]. The biasing circuit in microwave components knows to generate memory effect which has to consider in behavioral model [5]. The main task in power transistor process is self heating and the convert of electrical power to warmth will produce a specific modify in the device hotness which effect on the device characteristics such as the gain of power [6]. The distribution of any device temperature depends on class of operation which determined by DC bias condition and load conditions as well as the level of associated power [7]. Another important factor is thermal boundary conditions and trapping phenomena of different type are maintained to blame for power slouch [8]. To estimate the memory effects from traditional transistor description, the definite great signals transistor presentation at RF band and huge amplitude [9]. In general, the accuracy of power efficiency in GaN transistor at huge enter power starting linear parameters and dc components [10]. Many mechanisms create in extended phrase recollection are frequently nearby in transistor performance which produce more difficulties to separately identify the model in practical device [11]. The pulse partiality and pulse parameters quantity technology has deploying to achieve information about the device model to separate distinct memory [12]. The most difficult task is how convert this information into comprehensive dynamic model by many extra steps with many approximations. The trap state effect on both output charge storage and the current flow through the circuit is present in much study. Base on unusual statement regarding how the traps adjust the exhaust current has proposed by [13, 14] as illustrated in Figure 1

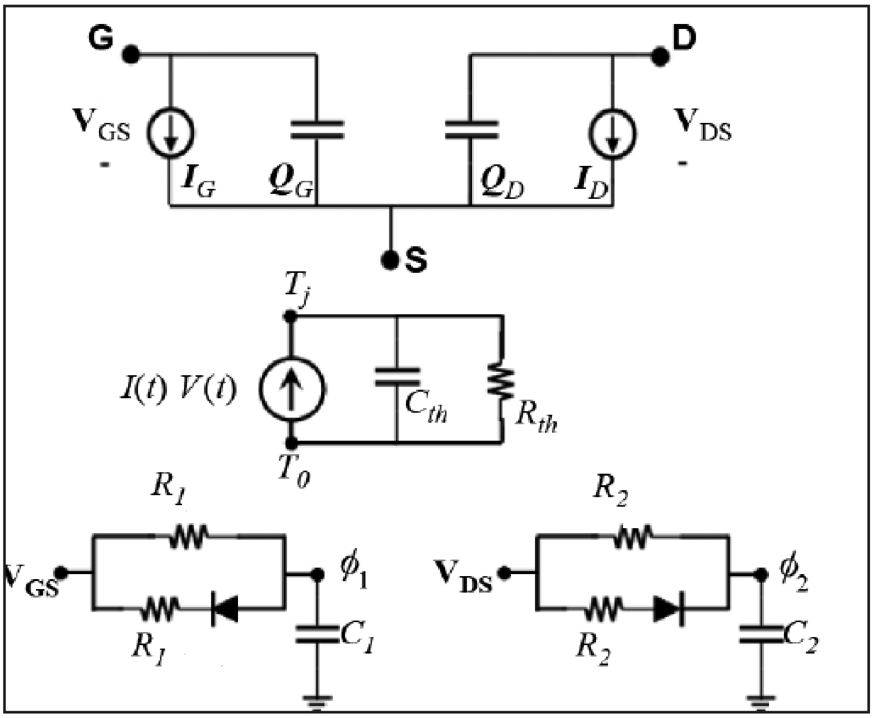

Figure 1: Equivalent circuit of nonlinear FET model[13, 14]

The trapping effects with high frequency memory of device which respond instantaneously to RF signals to occupied the dynamic load line for large scale has introduced by [15, 16]. The demonstrated of trap occupation depending on average time of bias emanation and rate capturing the length of active load line is projected by [17]. An overview of existing technology of modeling behavioral of microwave amplifier could be found in [18]. Through the last two decades, the silicon has dominated material in semiconductors device technology due to mature technology [19]. In the field of power device, the silicon is still dominating [20]. The silicon IGBT and MOSFET are widely used as power switch [21]. Hence, the power transistors for high voltage based on silicon has either relatively high resistance at MOSTFET or in less applications as in IGBT which consume high power [22]. Additionally, the maximum allowed operating temperature of silicon power circuits is 150-175 °C [23]. However, by [24]. In this work, the non-linear bipolar transistor circuit with low power consumption and less temperature associated in the transistors duty is presents as illustrated in Figure 1. The frequency response of non linear NPN transistor is shown in Figure 2

the design margins to prevent overheating band are small which need of new power device due to limitations of silicon and high power consumption. The quality of thermal resistance on junction temperature and power dissipated in power module parallel connection has been published

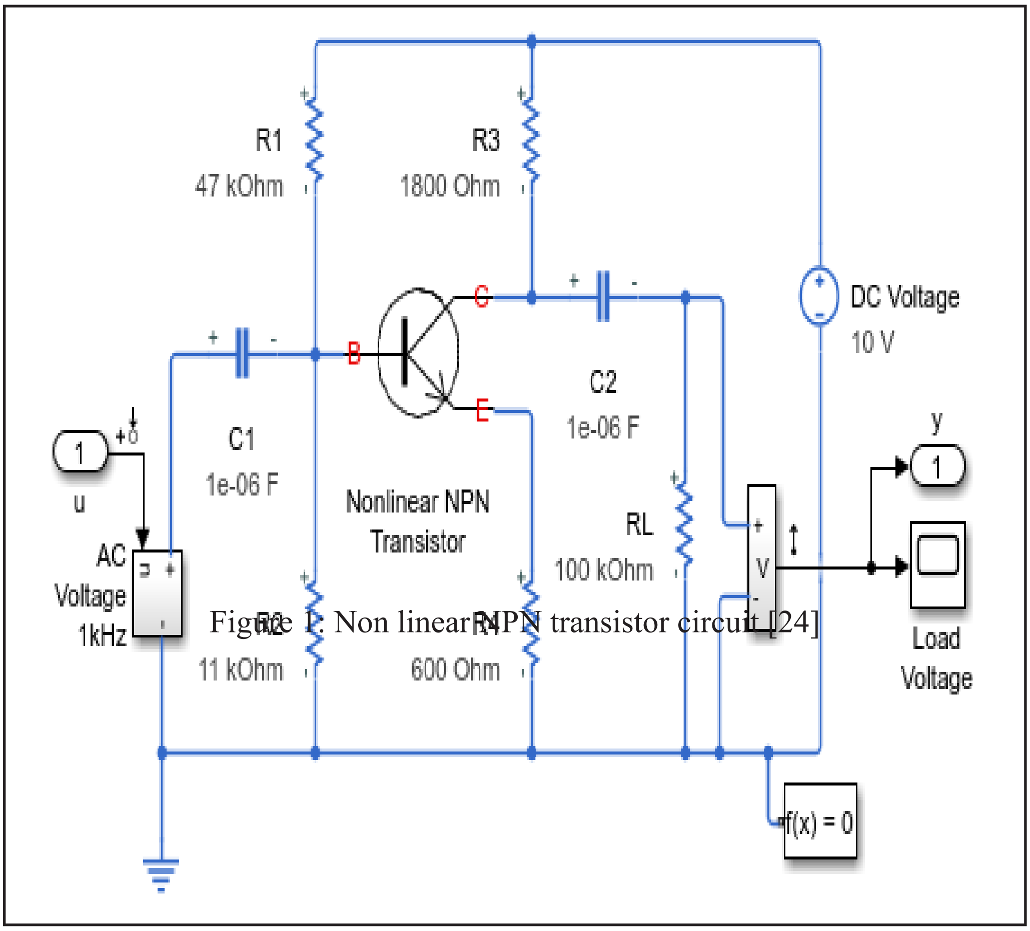

Figure 1: Non linear NPN transistor circuit [24] Figure 1: Non linear NPN transistor circuit [24]

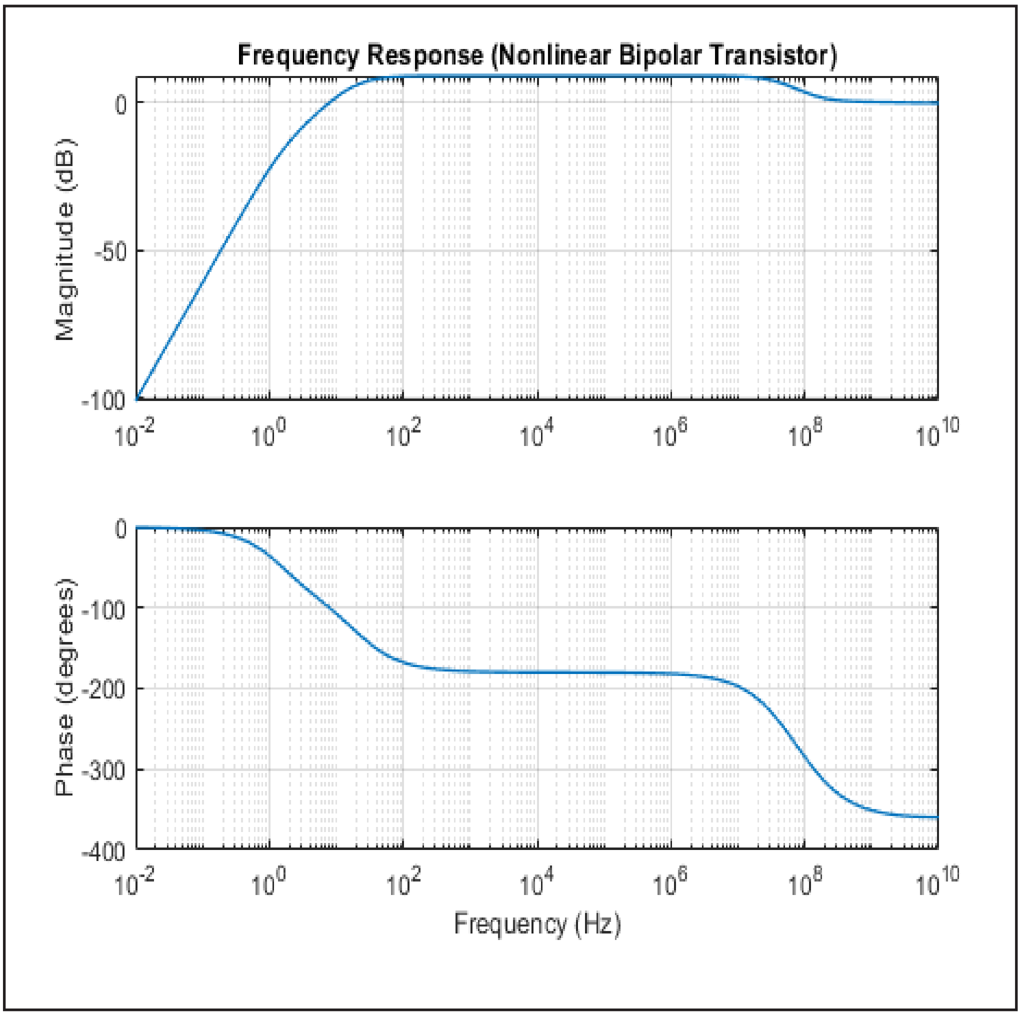

Figure 2: theoretical Frequency response of non linear NPN bipolar transistor

2.Nonlinear Bipolar Transistor model

The implementation of non linear bipolar transistor model has been designed in MATLAB SIMULINK environments. Figure 3 show the complete model with all elements. The resistance R1 and R2 are set at nominal operating points. The small signal gain is set by the ration of R3/R4 as approximation values. The decoupling capacitor of 1 uF has been chosen to present insignificant impedance at low frequency of approximately 1 KHz. For linearization, the model is configured for frequency response generation. The circuit of non linear NPN transistor is illustrated in Figure 4

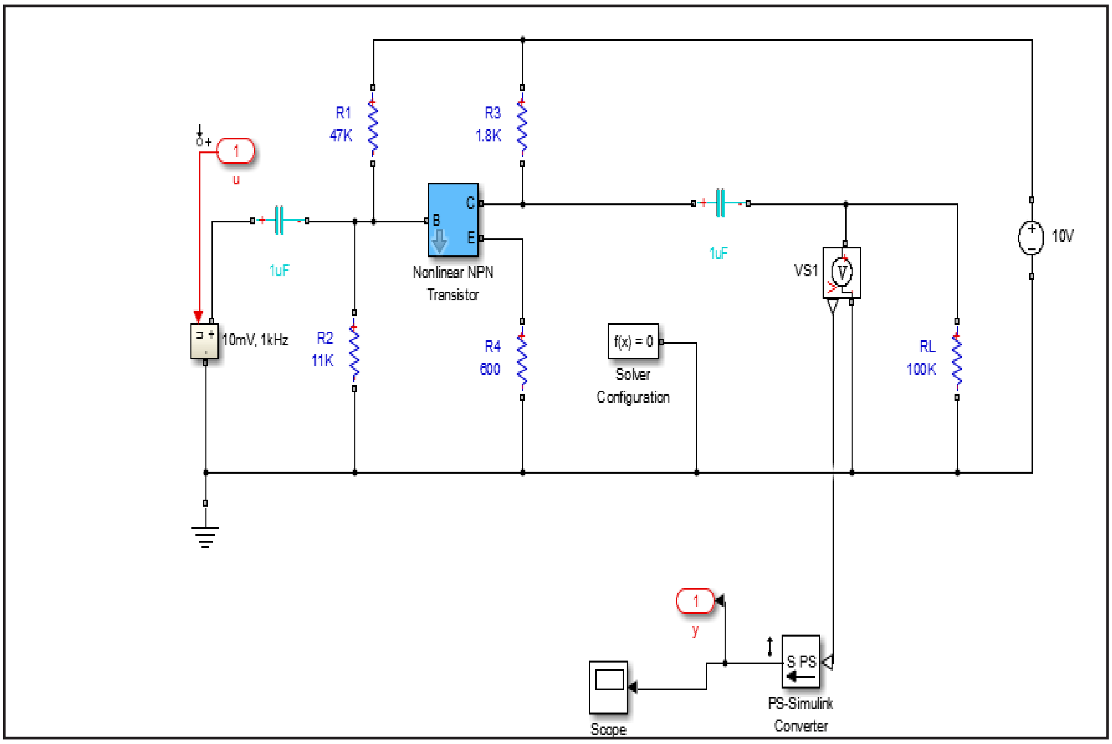

Figure 3: Non linear NPN transistor model

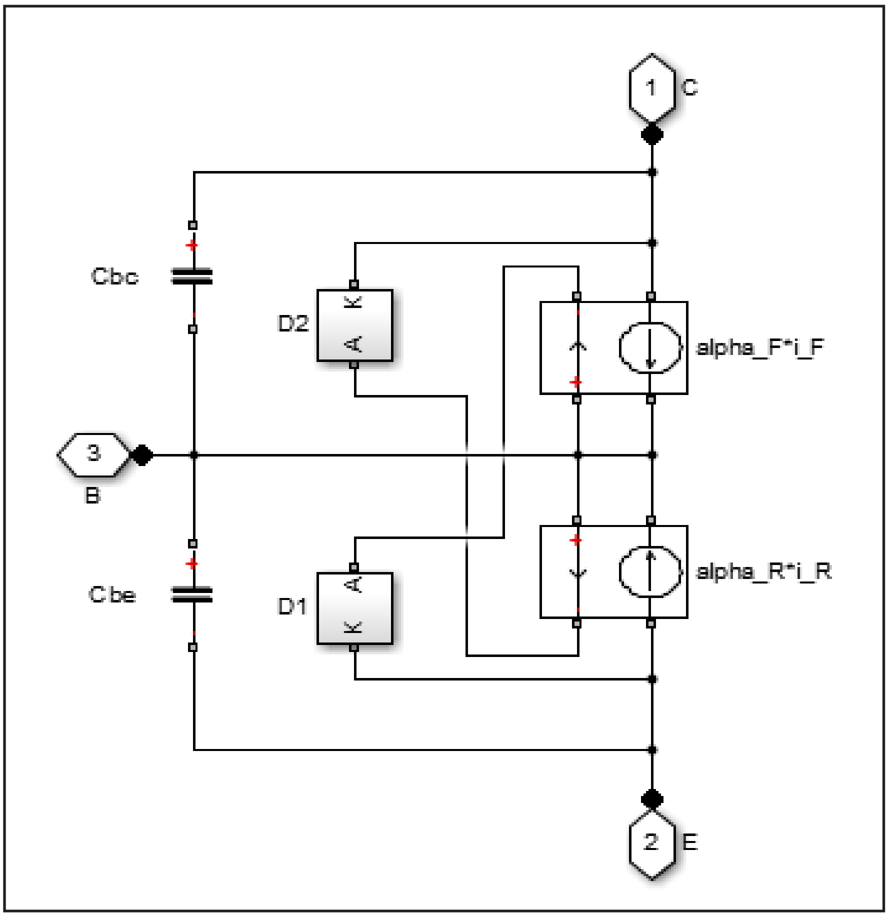

Figure 4: Nonlinear NPN Transistor

3. Results analysis

The frequency response is generated by running the model in MATLAB as illustrated in Figure 5 and Figure 6. In this case, the model illustrate the complexity could built from fundamental electrical elements such as transistor in the foundation library. In addition, one could show that the simulation has started from steady state option by set the solver of configuration block-set

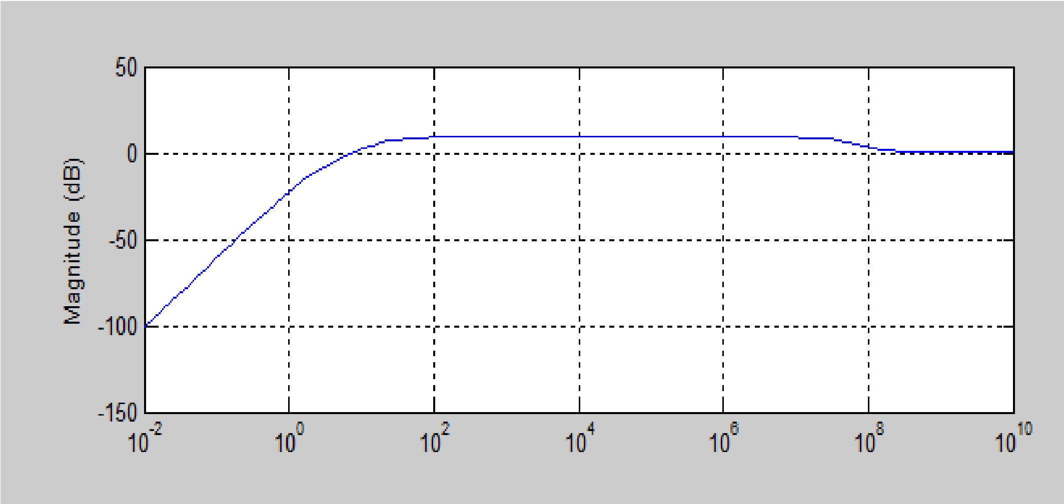

Figure 5 : Magnitude response of non linear NPN transistor

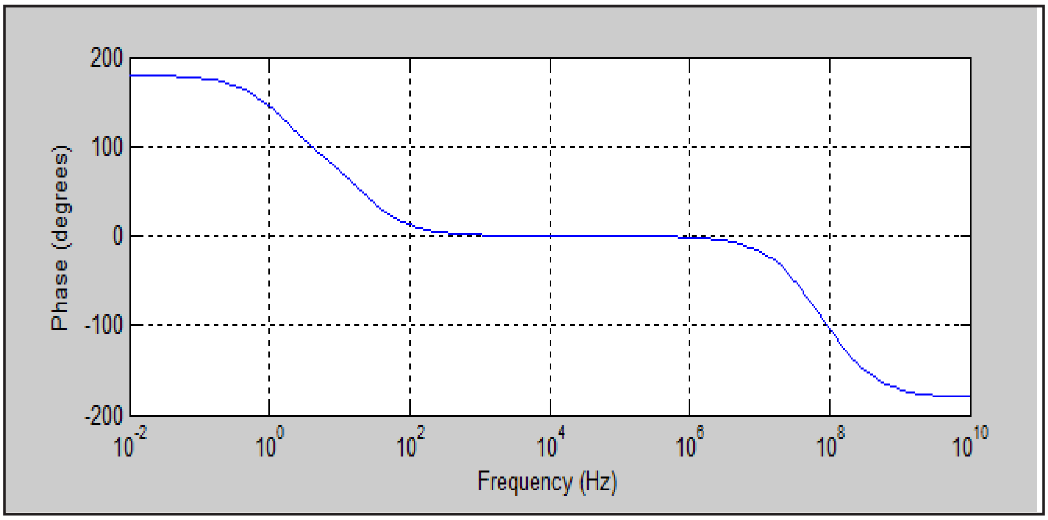

Figure 6: Phase response of non linear NPN transistor using MATLAB

The voltage and time relation of the proposed circuit show the steady state stabilization as illustrated in Figure 7

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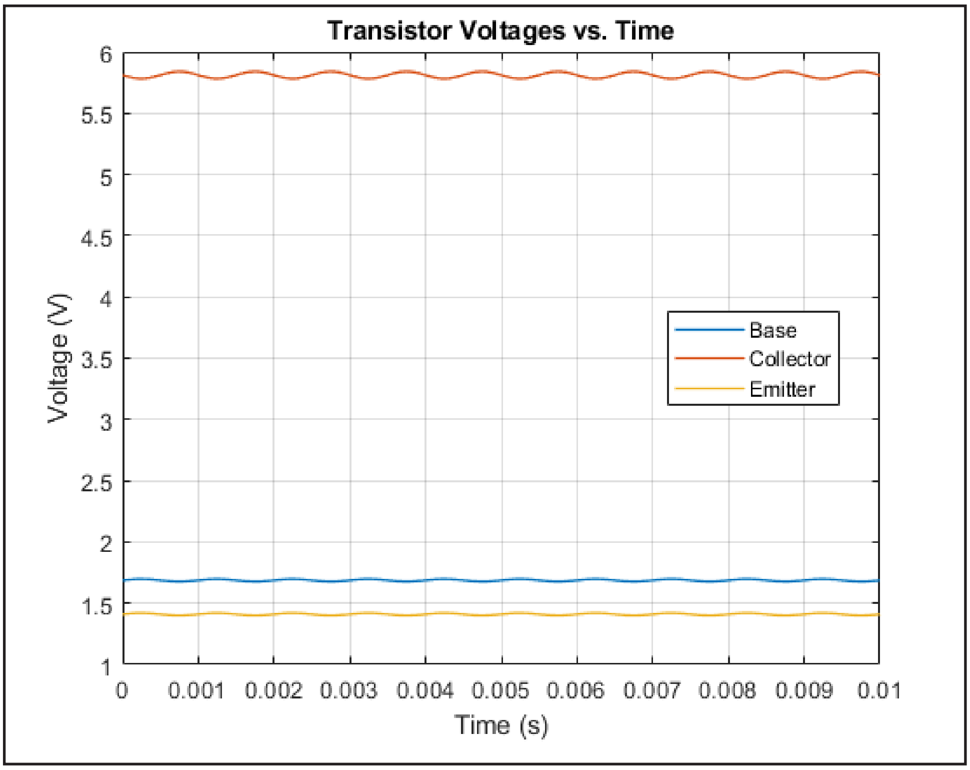

Figure 7: Relationship between voltage and time

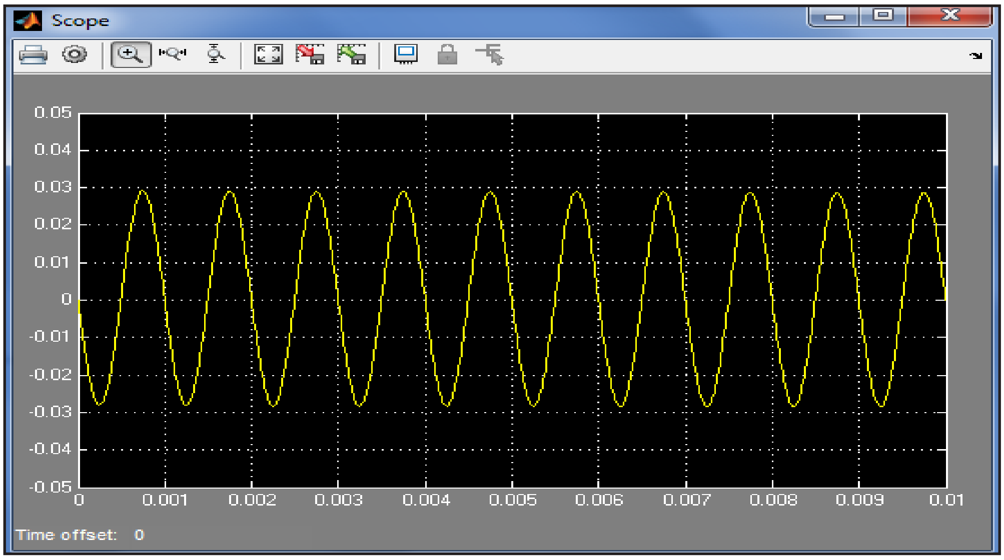

Figure 8: The output waveform at 1 KHz

Table 1 shows the main properties for different kinds of transistors. It's clearly illustrating the superior performance of nonlinear BJT transistor over HBT at high temperature. The nonlinear BJT transistor is preferred in power amplifier in high temperature application due to high gain and phase noise when used in communication circuits. In power amplification and oscillation, high power density and low

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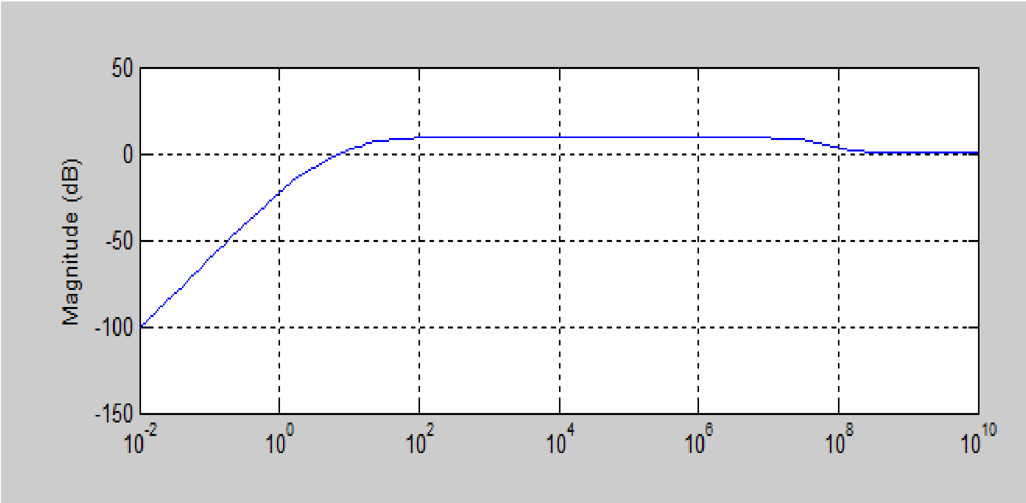
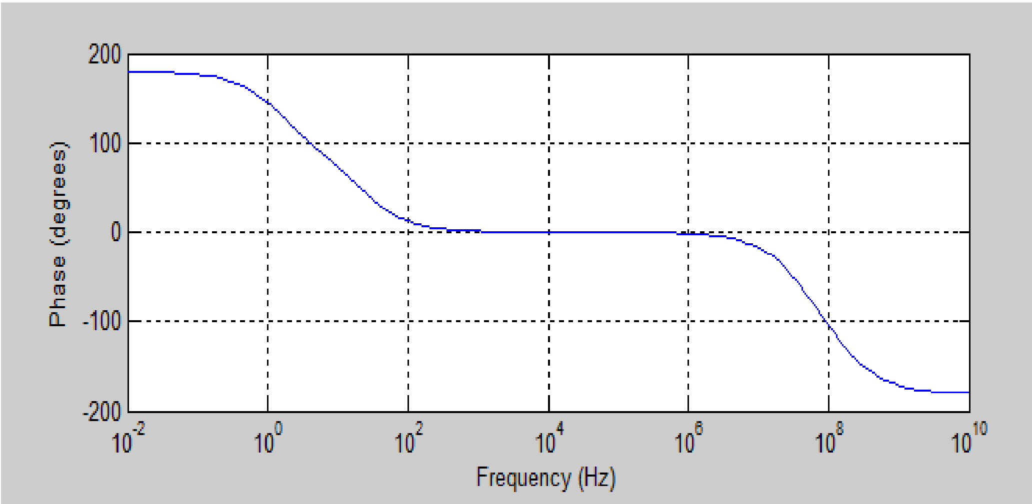


Figure 5 : Magnitude response of non linear NPN transistor



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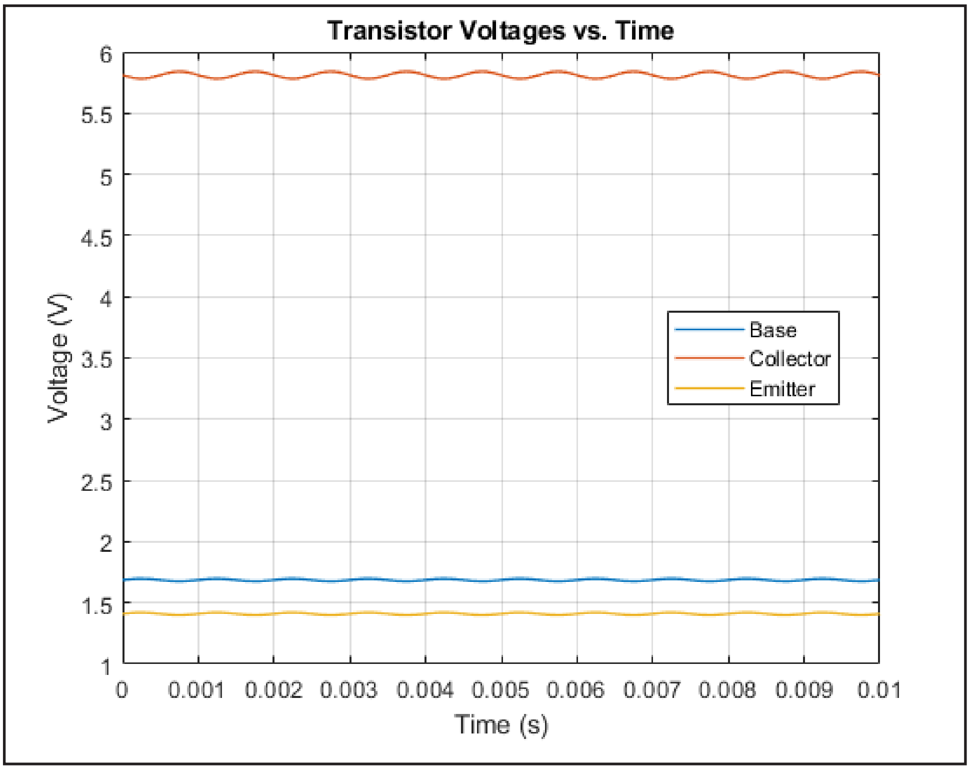

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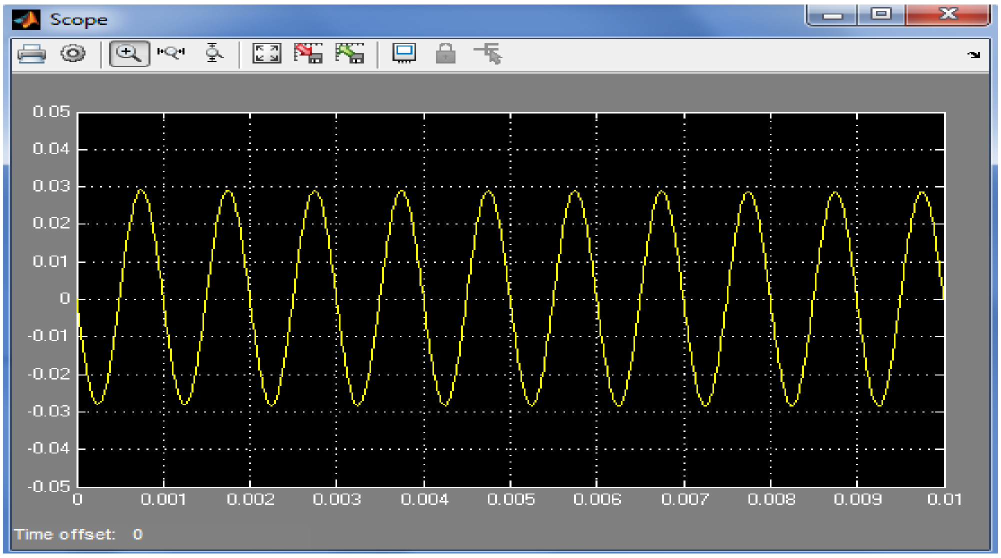

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