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Application of Electrical Networks Theorems in Transistors forIncreasing the Gain of Amplifier

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Abstract - This journal paper includes the relation between the electronics and the electrical engineering. There are various theorems in electrical networks which can be applied in the field of electronics as the maximum power transform theorem can be applied to the B.J.T.'s and other transistors for the derivation of certain properties which are temperature dependent as the value of the load resistor to be kept for the maximum power gain which leads to good voltage gain and current gain. It deals with how the theorems of electrical networks can be applied in the electronics and can be used. Generally we can use this technique only when the system is thermally stable as the temperature will be constant which will cause these equations to be valid. This paper deals about various techniques in which we can link the theorems of electrical networks in electronics. There are also some stability conditions which should be properly referred for the application of the techniques.

Keywords :attenuator, gm

1. INTRODUCTION:

1.1. TRANSISTORS (B. J. T., J. F. E. T., MOSFET) :

The types of transistors used in the field of electronics are mainly B.J.T.(BIPOLAR JUNCTION TRANSISTOR) , JFET(JUNCTION FIELD EFFECT TRANSISTOR), MOSFET(METAL OXIDE FIELD EFFECT TRANSISTOR).

All these types of transistors are being specified for their use in the field of electronics as a current amplifier or voltage amplifier or attenuator or for creation of a system which can pass a particular sought of bandwidth signal through it.

As if a signal has to be used for the amplification then the B.J.T. must be used in the proper sought of biasing as common emitter biasing. For passing a signal with a high frequency and to amplify it then we have to use JFET or MOSFET.

1.2. INTRODUCTION TO THEOREMS:

Actually there is a theorem that the product of the gain of amplifier and the bandwidth of the input signal is constant so both can't be increased simontenously so in order to increase the gain of the amplifier we can apply the theorems of electrical networks such as to find the value of load impedance on which the value of gain is dependent.

- GAIN OF COMMON EMITTER UNBYPASSED AMPLIFIER:

Generally in the case of B. J. T. we have the voltage gain and current gain. The gain is dependent on gm (transconductance), load resistance(R l) and the resistance in the collector region (Rc).

$$Av = gm(Rl/\ /\ Rc)$$

Condition that the B. J. T. is biased as common emitter (bypassed) biasing.

- WHAT HAPPENS TO THE TRANSISTORS IN THE LINEAR REGION OR OHMIC REGION.

Generally in the ohmic region the voltage on load over which we are taking the output is partially directly proportional the output current so it follows the ohm's law and also follows the condition of the constant temperature. As the transistor behaves as a linear device here in this region so we can apply here the various theorems of the networks analysis.

The basic concept is the application of the network theorems is for sustaining the gain of the amplifier let it be a B.J.T. or F.E.T.

1.3. MAXIMUM POWER TRANSFORM THEOREM.

According to this theorem if the value of the load resistance is kept same as the source resistance then the power dissipated by that particular load will be maximum (in the case of D.C. analysis) but if consider the A.C. analysis then the value of the load impedance should be the conjugate of the source impedence.

The paper includes the concept of first applying the concept of D.C. analysis of an amplifier and then the maximum transfer theorem in it. By this we get the value of the impedance of load and then taking the value of this load resistance we apply the voltage gain concept and we get the voltage gain is high. This theorem can be used for any kind of bandwidth frequency low or high.

1.4. LIMITATIONS TO THE THEOREMS:

But the theorem is strictly dependent on temperature as the value of load impedance change on the variation of temperature. Also the B.J.T., J.F.E.T. Aare sensitive to change in temperature so we derive the condition in the Δt so for differential time interval we have a differential change in the temperature as ΔT.

If we link the concept of MAXIMUM POWER TRANSFOR THEOREM then we have to apply the same concept to make a thevinin's equivalent circuit for that required B. J. T. 's we have to open circuit the load resistor. Meanwhile the process is done in order to find the value of the load resistor due to which there will be high sought of power deviation if there is high power transfer then there is high power gain.

2. CONCEPT INVOLVED:

2.1. IMPLEMENTATION OF THEOREMS:

The concept involves the introduction of the thevinin'stheorem in which the circuit is converted to an equivalent thevinin's circuit in which there is an equivalent voltage source called as V th, equivalent impedance Z th and load resistance.

The circuit involved or displayed consists of the D.C. circuit of an B.J.T. Now to convert to an equivalent thevinin's circuit we have to calculate V th and Z th.

Assume that the load impedance across which we are finding out the gain be open circuit. So apply the KIRCHOFF'S VOLTAGE LAW in the loops. Firstly, in this case we have the B.J.T. so it contains the different sets of voltage and the resistance offered by them. So let us consider that the resistance offered by them be negligible and they acts as the voltage source considering the case of Δt seconds and the temperature is not changing the resistance offered by the emitter-base-collector connections be nill and they acts a constant current source.[The value of V(be) i.e. the voltage across the base emitter region is variable as this region is highly temperature dependent considering the case of common emitter biasing.]

2.2. APPLYING THE THEOREMS:

Now applying the KVL equations over the loops so we have the equations in two loops considering only the D.C. analysis as follows:

The input loop in which the input signal is provided

$Vs-(Rb)I(b)-V(be)-(Re)I(e)=0$
……. Eq.1.

The second loop consisting of D.C. source

$Vcc-(Rc)I(c)-V(ce)-(Re)I(e)=0.$
……. Eq.2.

We know that value of $I(c)$ is β times the value of $I(b)$ and the value of I(c) is α times I(e).

So we have the $\alpha=\frac{\beta}{\beta+1}$.

By applying these equations we get

$$I(b)=\frac{\left(Vs-V(be)\right)}{Rb+(\beta+1)Re}$$

Put this in Eq.2..

$$V(ce)=Vcc-\frac{[\beta.Rc+Re.(\beta 1)]\left(\left(Vs-V(be)\right)\right)}{Rb+(\beta+1)Re}$$

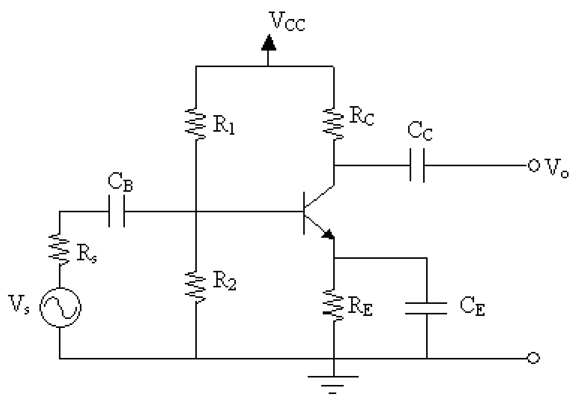
Now applying the K.V.L. in the loop 3 which consist of Vth and the load R l.

In the case of common emitter biasing the output is taken at collector so applying KVL

$$Vth=[I(e).R(e)+V(ce)]$$

$$Vth=Vcc-\frac{\beta(Rc+Re)\left(Vs-V(be)\right)}{Rb+(\beta+1)Re}$$

Now taking the case of Zthwe have to apply the theorem in which consider the voltage source as short circuit and the current source as open circuit. Then calculate the equivalent resistance across the open terminal.



As shown in the diagram we have three resistors across the terminal, there are connected in parallel connection. According to maximum power transfer theorem the value of load resistance will be same as the equivalent resistance across the open terminal.

We have the equivalent resistance as $Rb//Rc//Re$.

Therefore, the value of the load resistor will be equal to $Rb//Rc//Re$.

The value of I sc will be $\frac{Vth}{Rth}$

Now the power dissipated will be the maximum power as

$$P=Vth*Isc$$

$$P=\frac{\left(Vcc-\frac{\beta(Rc+Re)\left(Vs-V(be)\right)}{Rb+(\beta+1)Re}\right)}{Rb//Rc//Re}$$

2.3. CONDITION OF STABILITY AND COMPENSATION TECHNIQUES:

Now, the power dissipated will be maximum this means that the power gain is high with respect to a simple circuit. So this power gain will lead to gain in the voltage and current. So by this method one can increase the gain of an amplifier. As in the equation we have the power deviated id dependent on Vc c, β, Rc, Rb, Re, Vs, V(be), V(ce). Out of it Vcc, β, Vsare independent on temperature, so they don't need any kind of stability.

But there is alwaystendency of the voltage of voltage sources changing due to the changing of temperature. So there is the case of temperature stability in it as the temperature should be maintained to a constant value.The stability consistof the voltage Vbe, Vce, Re, Rb, Rc.

The stability factors are:

- Stability of $Vbe = \frac{\Delta Vbe}{\Delta T}$.

The stability should be as low as possible in order to increase the gain as high as possible. It should be ideally as 0.

- Stability of $Vce = \frac{\Delta Vce}{\Delta T}$

The stability should be as low as possible in order to increase the gain as high as possible. It should be ideally as 0.

- Stability of $Re = \frac{\Delta Re}{\Delta T}$

The stability should be as low as possible in order to increase the gain as high as possible. It should be ideally as 0.

- Stability of $Rc = \frac{\Delta Rc}{\Delta T}$

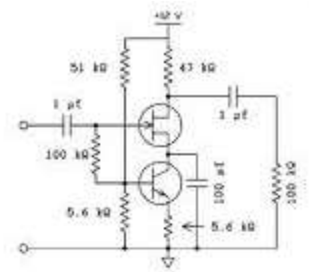
The stability should be as low as possible in order to increase the gain as high as possible. It should be ideally as 0.

- Stability of $Rb = \frac{\Delta Rb}{\Delta T}$

The stability should be as low as possible in order to increase the gain as high as possible. It should be ideally as 0.

If all these stability factors are controlled then the gain of the amplifier will be increased. For the control of these stability factors many compensation techniques are evolved as the diode compensation for voltage compensation; thermistor compensation, resistance temperature compensation etc. for resistor compensation.

In order to increase the gain of amplifier we can use the following method to increase the gain of amplifier and to create a system of transistors which could allow the gain to be maximum and also allow the high incoming frequency in the input. The following diagram shows the B.J.T. and F.E.T. connected in series so to increase the gain of the amplifier and also to allow a high sought of input frequency.



2.4. APPLICATION OF THE CONCEPT IN F.E.T. AND MOSFET:

If this concept is applied in the ohmic region of F.E.T. then it is more fruitful as here the voltage is considered proportional to the current flowing so it follows the Ohm's the law which works on the condition of constant temperature. If this condition is used then the use of compensation techniques will be less, it saves the human effort and also the amplification is done.Since in case of F.E.T. we can use the signal with high bandwidth frequency so it can have the profit of using the high frequency and amplification. Also in case of MOSFET this condition can be used. As in the case of MOSFET we can have the high input frequency signals to be passed in the input side.

3. CONCLUSION:

This paper consists of relation of theorems of electrical networks with electronics. Especially MAXIMUM TRANSFER THEOREM linked with B.J.T.'s and F.E.T.'s. This is done in order to increase the gain of the amplifier. The concept is applied to voltage gain as it depends on the load resistance of resistor. So modifying that value of load resistor in such a way that the gain of the amplifier can be increased. Various compensation techniques which will be involved are listed and the stability factors of voltages and resistances with respect to temperature are also mentioned.

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