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Electronic Devices (ELECTRON FLOW VERSION) , Ninth Edition Content Table Chapter 1: UPDATE IN ELECTRONICS Chapter 2: DIODES AND ADD Chapter 3: SPECIAL-PURPOSE DIODES Chapter 4: BIPOLAR JUNCTION TRANSISTORS Chapter 5: TRANSISTOR BIAS CIRCUITS Chapter 3: BJT HEAD AMPLIFIERS 7: POWER AMPLIFIERS CHAPTER 8: FIELD TRANSISTORS (FETS) CHAPTER 9: FET AMPLIFIERS AND SS SCHEMES CHAPTER 10: AMPLIFIER AMPLIFIER RESPONSE CHAPTER 11 : THYRISTORS CHAPTER 12 : SOURCE AMPLIFIER Chapter 13: BASIC OP-AMP CIRCUITS Chapter 14: SPECIAL-PURPOSE OP-AMP CIRCUITS Chapter 15: ACTIVE FILTERS Chapter 16: OSCILLATORS Chapter 17: VOLTAGE REGULATORS Chapter 18: BASIC PROGRAMMING Concepts FOR AUTOMATED TESTING ONORAL CHAPTER 19: COMMUNICATIONS Other links, tripole and quadripolis. Include linearity concepts. Illustrate the theory with volt-amplifier characteristics, symbols, mathematical and diagrams of models. 1 INTRODUCTION IN rice. 1.1 We present a concentrated bipolis with accompanying current and voltage directions. For this bipolar, we can express the following instant meanings: rice. 1.1 - Representation of the bipolar. VAB (t) - VA (t) - VB (t), (1.1) and pAB (t) - VAB (t)iA (t), (1.2) in which: VAB (t) represents a complete instant voltage between Terminals A and B bipol; VA (t) represents instant general voltage in Terminal A; VB (t) represents instant total voltage in Terminal B; iA (t) is a full instant current that enters terminal A and exits Terminal B; pAB (t) is an instantaneous power developed between terminals A and B; The zab is a complex distinction between terminals A and B. If pAB (t) 0 W, the bipolar works as a receiver. If pAB (t) 0 W, the bipolis works as a supplier (or generator). 1-2 Chapter 1: STUDY ON BIPOLO TRIPOLO AND QUADRIPOL 1.1 COMPONENTS CC AND DC VOLTAGE AND CURRENT In this section we discriminate against CC (continuous component, or medium component) and AC (variable component) of voltage and current components, in terms of notation. In general, VAB (t) and iA (t) can be expressed as a function of their CC and AC components, as follows: VAB (t) - VAB and Vab (t) (1.3) iA (t) (1.4) and AI ia (t) . In which: VAB is a continuous component, CC, or vab average (t); Usually represented by VCC or Vmida; Vab (t) represents the instant voltage of the variable component, AC, VAB (t); VCA (t) is usually presented. AI is a continuous component, CC, or average AI (t); Usually represented by the ICC or Imedia; ia (t) is an instant current of the variable component, RIGHT, iA (t); iCA (t) is usually presented. Lowering the direction of the poles and B, capital voltage and current marks can be rewritten as follows: V (t) - VCC - VCA (t) or V (t) - VMEDIA (t), Vm'dia VCC (1.5) i (t) - Imedia and iCA (t), with Imedia ICC. (1.6) and i(t) - ICC and iCA (t) or EXAMPLE 1.1: Be V (t) VCC No 10 B and with 2-f 2-/T, then VCA (t) 15sen ('t) v. In pic. 1.2 we show V (t) and its CC and CA components. We have noticed that the graphic amount of VCC and VCA (t) corresponds to form V (t). Forms V (t) and VCA (t) can be visualized on the Oscilloscope screen using one of its input channels. When the channel scales, the CC appears to be Form V(t). The VCA (t) scale shows the shape of the VCA (t). NELSON JOSE CAMELO - DEE-UFMA 1-3 NELSON JOSE CAMELO - DEE-UFMA Placing v (t) signal on two Oscillatorscop channels; Choice: The CC scale of the first channel and the AC of the second; by activating the second channel inversion button and the two-channel sum button, we get a VCC trace on the Oscillation screen. In section 1.3, we present mathematical models of average voltage, medium current and average power. In section 1.4, we discriminated against DC and DC power components. To do this, we looked at the concept of the average in general, in section 1.2. Fig. 1.2 - Discrimination of CC components and V(t). 1.2 Averages of DISCRETE AND CONTINUOUS VARIABLES Consider xi X1, X2, X3, ... , XN / i 1, 2, 3, ..., N. Thus, N x 1 N i Xmean xi N N i 1 i 1 (1.7) In this case x discrete variable. Let's now consider x as a continuous variable in time, i.e. x as function t, or x/t, with t 0, T. So Xmean T 0 x/t 1 T x(t) dt. T T 0 (1.8) BASIC ELECTRONICS 1-4 Chapter 1: STUDY ON BIPOLO TRIPOLO AND quadRIPOLO We have observed similarities between the formulas for calculating the average, both discrete and continuous values. There is, therefore, ambiguous correspondence of equivalence: - , N, T, xi , x(t), i t and I y 1, 2, 3, ..., y t 0, TK. 1.3 MEDIUM VOLTAGE AND POWER EXPRESSIONS From the general definition of Xm'dia, we can write for voltage v(t), current i(t) and power p(t), their corresponding medium voltage (Media), medium current (medium) and medium power (Pm'dia), as follows: 1 T v (t)dt . T 0 Vmedia - Medium (1.9) 1 T i (t)dt and T 0 Pm'dia (1.10) 1 T p/t) dt . T 0 (1.11) 1.4 COMPONENTS CC AND POWER CA We return to the power case for bisexual figs 1.1, in which pAB (t) - VAB (t)iA (t), Eq. (1.2). In addition, by lowering the indication of poles A and B, as we did in section 1.1 for voltage and current, the total instantaneous power can be rewritten as: p/t - V (t)i (t). (1.12) Now using the components DC and CA v(t) and i (t), Eq. (1.5) and (1.6), results: «VCC » V CA (t)» (МТП) и «Пмедия» (1,13) 1 T 1 T 1 T t (t) dt (v, t)i (t)dt . VCC vCA (t) T 0 T 0 T 0 1 T 1 T 1 T TCC I CCdt и VCC ' iCA (t)dt (ICC) vCA (t) dt НЕЛЬСОН ХОСЕ КАМЕЛО - DEE-UFMA 0 (1,14) 0 t vCA (t)iCA (t)dt T 0 (1.14) 1-5 NELSON JOS' CAMELO - DEE-UFMA Pm'dia - VCCICC - 1 T vCA (t)iCA (t)iCA (t)dt T 0 PCC и PCA с 1 T vCA (t)iCA (t)dt . T 0 (1.15) (1.16) Мы заметили, что PCA является постоянным, потому что это результат определенного интеграла. Поэтому мы не можем путать Пмедию с PCC. PCC - это лишь малая часть Пмедии. Таким образом, очевидно, что как непрерывные, так и чередующиеся компоненты, ток и напряжение, производят среднюю мощность, Eq. (1.15). 1.5 RELATIONSHIP BETWEEN ENERGY AND POWER Be E (t) представление энергии во времени, связанное с биполем; и 'E't0), его энергетическая вариация в промежутке времени (0, t). Так, dE (t) p(t) или dE (t) - p(t)dt dt t p(t)dt , изменение энергии, рассчитанное в диапазоне от 0 до т, или t -0 dE (t) T0 и -E T0 (T 0 t p(t)dt 0 или, p(t)dt или (1.17) (1.18) (1.19) (1.20) 1 T p(t)dt)T (Пмедия)T или T 0 (1.21) 3Э No0n T (Пмедия)nT, c n No 1, 2, 3, ... и (1.22)E 0n T й n-E T0 . (1.23) EXAMPLE 1.1: Если постоянная мощность в биполе составляет 600 Вт, какова его энергетическая вариация в 100 мин? РЕШЕНИЕ: мин 'E 100 й 0 100 0 600dt й (600 Вт) 100 мин и 6 кВт-ч. (1.24) BASIC ELECTRONICS 1-6 Chapter 1: STUDY ON BIPOLO TRIPOLO AND QUADRIPOLO EXAMPLE 1.2: Если средняя мощность в биполе составляет 400 Вт, какова его энергетическая вариация за 100 периодов? Период составляет 1/60 с. РЕШЕНИЕ: E 0n T (Пмедия)nT (600 Вт)(100)(1/60 с) 6 кВт-ч. (1.25) EXAMPLE 1.3: Если изменение энергии в биполе составляет 360 Вт в период, какова его вариация в 100 периодах? РЕШЕНИЕ: 3.Э. No 0n T и н-E T0 - 100 (360 Вт) - 10 кВт/ч, с n 100. (1.26) 1.6 EFFECTIVE VOLTAGE AND CURRENT VALUES Мы вычислим среднюю мощность, рассеянную в резисторе сопротивления R, подвергаемому напряжению v(t). Итак, из ЭК. (1.11) и (1.12): Пмедия No 1 T 1 T v (t) 1 T 1 T 2 v v (v (t) t (t dt dt - й - T 0 R T 0 T 0 R (1.27) Pm'dia - 1 T 1 T 1 T 1 T p(t)dt - v (t)i (t)dt - Ri (t)i (t) dt - R ' i 2 (t) dt . 0 0 T T T T 0 (1.28) Если в (1.27) набор: 1 T 2 2 v (t)dt и Vef2 VRMS , то, Веф и VRMS - 0 T 1 T 2 v (t)dt . T 0 (1.29) Если в (1.28) мы устанавливаем: 1 T 2 i (t)dt - I ef2 I 2RMS , то Ief и IRMS - 0 T 1 T 2 i (t)dt T 0 (1.30) Таким образом, средняя мощность, поставляемая резистору R v(t), or current i(t) given: NELSON JOSE CAMELO - DEE-UFMA 1-7 NELSON JOSE CAMELO - DEE-UFMA 1 1 T 2 V2 - v (t) dt RS i 2 (t) dt - R I ef2 , T 0, in which: Pm'dia and Vef (1.31) (1.32) - called voltage or effective value v(t) VRMS - is called voltage value or RMS (Root Means Square) v(t). Both notations are equivalent, so they have the same value. This means that if v(t) is replaced by a continuous vef voltage, it will produce the same power in the R resistor in the same period as shown in the pic. These two R schemes are the same. Be Pmedium-1 power supplied by Resistor R source v (t) in chain-1; and Pmedia-2 supplied by the same Resistor R by the Wef source, under the scheme-2. So if Pmedia-1 and Pmedia-2, Wef is an effective value v/t). The same can be said about Ief or IRMS i(t). It is important to note that this is an equivalence between energies. Fig. 1.3 - Equivalence between v(t) and its effective value, Vef; and between i(t) and its effective value, Ief. 1.7 EFFECTIVE POWER IN RESISTIVE LOAD By multiplying, member by limb, eq. (31) and (32), we have: Vef2 2 2 2 (Pmedia) Ief R No 2 Vef Ief Vef Ief vefVef Ief . (1.33) From Eq. (1.33): Pmedia and Wef Ief - PRMS and Pef. (1.34) Relationships shown in Eq. (34) is also called RMS power, effective or active. PRMS as a 100% weff product Ief, as shown in Eq. (1.34), occurs only when the load resists, implying a current in the voltage phase, as does BASIC ELECTRONICS 1-8 Chapter 1: STUDY ON BIPOLO TRIPOLO AND QUADRIPOLO, expressed in the eq. (1.35). In other cases, an option called the power factor appears, as seen on Eq. (1.41). 1.7.1 EFFECTIVE POWER AND PEAK POWER IN RESISTIVE LOAD Let's look at the case of rice. 1.3, in which: v(t) - Vpsen ('t) and i(t) - Ipsen ('t). (1.35) Entry from v(t) to Eq. (1.29) we have: 1 T 2 v (t)dt - T 0 Vef - VRMS - VP 1 T 2 1 T 2 v (t)dt V sen (wt) dt p T 0 T 0 0 2 (1.36) Entry with i/t) na (1.1) 36) 1.30) we have: Ief and IRMS - IP 1 T 2 1 T 2 i (t)dt I sen (wt) dt p T 0 T 0 0 2 (1.37) Relationships (1.36) and (1.37) show that in this case sinus, The peak value under square root 2 determines the corresponding effective value. In rice. 1.5 Together with table 1.1, we show the different relationships that are derived for each particular wave form. Объединение Eq. (1.34), (1.36) and (1.37) this leads to R resistor: PRMS - Vef Ief - Vice President I P P - P P P 50%PP 2 2 2 2 2 (1.38) from Eq. (38): PP and VP I P (1.39) Ratio shown in Eq. (1.39) is called peak power. Teh how it appears in Eq. (38), PRMS is equal to 50% PP, valid only in this case, when the load resists implying current in the voltage phase, Eq. (1.35), and stress is considered sinus. Be in the case when the load is not resistor and therefore the current is not doo in relation to the voltage as shown in Eq. (1.40): NELSON JOSE CAMELO - DEE-UFMA 1-9 NELSON JOSE CAMELO - DEE-UFMA v(t) - Vpsen ('t) and i(t) - Ipsen (-t'). Entering with (1.40) in (1.11), we have: Pm'dia No 1 T p(t)dt T 0 1 T (1.40) - V sen ('t) IP sen ('t -) - T 0 P VP IP cos ( ) No2 (1.41) In ratio (1.41), fc and cos ( ) are called power factor. 1.8 EFFECTIVE DC AND DC VOLTAGE AND CURRENT COMPONENTS In Section 1.1, we discuss DC and AC and voltage components. Now we show how these components are part of the formation of effective values. To do this, we introduced Eq. (1.5) on Eq. (1.29) and we develop as follows: Vef2 No 1 T 2 1 T v (t)dt (VCC vCA (t) 2 dt vCAdt - vCA (t) 0 0 T 0 T T T T (1.42) - 2 VCC 2 VCC - 0 - 1 T 2 vCAdt - T 0 Vef2 q CA , From ratio (1.42) we noticed what' is: Vef2 qCA No 1 T 2 1 T 2 T 2 T 2 vCAdt Vef-CA VCA DT and VCC VCCdt VCC - VCC dt - 0 T T T T T T 0 (1.43) We come to the conclusion that in Eq. (1.42): (a) Vef-CA is an effective value only of the CA v(t component), i.e. vCA (t); b) The effective value of the constant, in this case, the VCC, is the vcc itself. Also, watching the relationship, Eq. (1.42), in its square format, we can conclude that: Vef No. 2 VCC Vef2 q CA. (1.44) With the same procedure, but using eq. (1.6) and (1.30) we can also conclude that in the case of current: Ief No. 2 I CC I ef2 qCA , (1.45) with Ief-CA, representing the effective value of only the CA i (t) component, i.e. iCA(t). BASIC ELECTRONICS 1-10 Chapter 1: STUDY ON BIPOLO TRIPOLO AND QUADRIPOL Way to remember the results shown in eq. (1.44) and (45) is to link them to the relationship between the hypotenuse and the catheters of the right triangle of the pyphagorus theorem, as shown in the pic. 4. Rice. 4 - The relationship between cc, AC components and effective voltage and current value. From the relationship 1.44 and 1.45 we come to the conclusion that: a) the overall effective value is always higher than any of its components, as it is represented by the hypotenuse of the triangle, rice. 1.4: (b) there is no negative effective value because it is the result of the square root of the quadrangle function of the integral. 1.9 TYPICAL WAVEFORMS OF ELECTRICAL ENGINEERING In Fig. 1.5 we show some wave shapes widely used in electrical engineering. Next to the picture, we'll fold table 1.1 with value calculation formulas All effective - Vef, medium - Vmidi, and only variable component - VefCA of each wave form. Sinus, triangular and square wave shapes are typical or primary in electrical engineering. Any equipment for generating functions includes at least these three wave shapes. Of these, other wave shapes can be easily generated by analog circuits of the processor. NELSON JOSE CAMELO - DEE-UFMA 1-11 NELSON JOSE CAMELO - DEE-UFMA Table 1.1 - Stress associated with wave figures shown in rice. 1.5, next to him. Wef Vmedia Vp 0V Beth-CA Vp 2 2 Vp 0V Vp 0V 3 3 Vp Vp 2 2 Vp 2 Vp 2 Vp 2 Vp 2 Vp 2 V VP0 2 (P1) () 2 2'2 q Vp1 VP 0 2 (VP1 - VP0 2 '2 Reece). 1.5 - Common wave shapes in electrical engineering. 1.10 TRUE EFFECTIVE AND EFFECTIVE VALUE MEASUREMENT In a multi-meter area we have two scales for voltage measurement. One only to deal with CC values and one only for CA. In the CC scale, we measured the average voltage. At CA, we measure only the effective value of the CA component. Then, to calculate BASIC ELECTRONIC VALUE 1-12 Chapter 1: STUDY ON BIPOLO TRIPOLO AND TOTAL EFFECTIVE QUADRIPOL We used triangular ratio, rice. 1.4, Section 1.8, whose formulas for this we repeat below: Vef No. 2 VCC Vef2 CA and Ief No. 2 I CC I ef2 qa . (1.46) Some multimeters have the TRUE RMS function. Even these multimeters, like everyone else, measure the COMPONENTS of CC and AC separately. The difference is that the TRUE RMS multimeter measures the effective value more accurately, even from wave forms not so consistent with those shown in the pic. 1.5. 1.11 OR LINEAR CIRCUITS Systems can be classified differently, depending on the models assigned to them. Thus, they can be framed as: analog, digital, stationary, discreet, linear and nonlineary, to name a few. In this text we are interested in discussing only the categories of systems, or circuits, linear and non-linear 1.11.1 PROPERTIES OF LINEAR SYSTEMS Consider the system or electrical circuit f, pic. 1.6, which when excited E (t) meets S (t), so that S(t) f(E(t)). Fig. 1.6 - Block view of the electrical circuit f. If: for E (t) - E1 (t), F(E1(t) - S1 (t), for E (t) - E2 (t), F(E2 (t) - S2 (t), for E (t) - E1 (t)2(t), f(E1(t) - E2 (t) - f (E1(t) - f'E2(t) - S1 (t) - S2 (t), then we say that the system satisfies the property of aditio. If: for E (t) - En (t) f(en(t) - Sn (t) and for E (t) - kEn (t) f (kEn(t) - kf (En (t) - kSn (t), in which k equals any real value and n' (1, 2, 3, ...); then we will say that the system satisfies the property of homogeneity. Any system that satisfies these two properties at the same time is said to be linear. the scheme is not linear, so it is non-linear, and vice versa. In this classification of linear or non-linear, we do not take into account the initial conditions of the system. In the Reece block. 1.6, E't and S(t) are common variables, meaning they can represent any electrical quantity, NELSON JOSE CAMELO - DEE-UFMA 1-13 NELSON JOS' CAMELO - DEE-UFMA is the most common voltage and current. This block may represent a system, a circuit, or just a two-legged one, such as a resistor. Fig. 1.6a - Illustration of the property of the pried. Fig. 1.6b - Illustration of the properties of homogeneity. 1.11.2 PRINCIPLE OF SUPERPOSITION Consider the electrical system or circuit presented by block f, pic. 1.7 that, while Arousing X (t) and Y(t) meets S(t), so that S (t) f (X(t), Y (t)). Fig. 1.7 - Block view of the linear system. Be input X (t) and Y (t), data: If X (t) k1X1 (t) - k2X2 (t) and Y(t) m1X1 (t) - m2X2 (t) Be S (t) system response, this: S(t) f(t) - f ((k1X1(t) - k2X2 (t)), (m1Y1 (t) - m2Y2 (t) This answer summarizes the two properties of linearity, so this system of two inputs is linear. In Figure 1.8a and 1.8b we illustrate linearity properties for each input X (t) and Y (t) individually. These two expressions summarize the so-famous principle of superposition illustrated in rice. 1.9. BASIC ELECTRONICS 1-14 Chapter 1: STUDY ON BIPOLO TRIPOLO AND QUADRIPOLO Fig. 1.8a - Illustration of linearity properties for X(t). Fig. 1.8b - Illustration of linearity properties for Y/t. Fig. 1.9 - Illustration of the superposition principle. 1.11.3 LINEAR CIRCUIT CHARACTERISTIC A graph of the relationship between signals S and E is called transmission characteristic, which is highlighted in a pair of axes by the quantity units that represent these variables. For example, the characteristic V-A (Volt-Amper), the characteristic C-V (Coulon-Volt), the characteristic V-V (Volt-Volt), etc. in rice. 10 We show linear relationship S vs. E. Fig. 1.10 - Linear chain characteristics with enter E and exit S. In pic. 1.11 we show a basic example of a linear chain (a resistor powered by a current source) with a characteristic V-A. Next, we prove that it satisfies the properties of additive and homogeneity. (a) (b) Rice. 1.11 - an example of a linear chain; V-A function. v(t) - f(i(t) - Ri (t), then: f(i1) - Ri1 (t) NELSON JOSE CAMELO - DEE-UFMA 1-15 NELSON JOSE CAMELO - DEE-UFMA F (i Ri2 (t) f(i1 - i2) - R (i1 - i2) - Ri1 (t) - Ri2 (t) - f (i1) - f (i2), satisfies reception property; f())i) - R (-i) - (Ri) -(f) satisfies the property of homogeneity. Fig. we show an example of an RC scheme in which i(t) f(v(t)). For this chain, omitting the independent variable, t, we can write the following relationship: pic. 1.12 - RC Linear Scheme. di dv i and f(v) and i - CR dt and C dt . Be v q k1 v1 and k 2 v2, then we can draw a conclusion as follows: C d (k1 v1 q2 v2) dt q c (k1 v1) dt q C d (k2 v2) dt q1 C d (v1) dt q2C d(v2) dt f (k1v1'k2v2) - f (k1v1) 1.11.4 NON-LINEAR CIRCUIT CHARACTERISTICS Imagine a device whose V-A feature is represented by model v mathematician i f(v) - Is (e━VT -1); and the other i q f(v) - IDSS (1 - V)2 . We clearly noticed P that the first feature is exponential and that the second function is square. Further, we prove that none of them satisfies the property of homogeneity. It is enough that one of the properties of linearity is not satisfied, so we say that the device, in the analysis, is non-linear. In the case of the first device: (v f(v) - Is (e━VT No. 1) - f(v) (e━VT No 1); In the case of the second device: (v f(v) - IDSS (1 - V)2 - f(v) - IDSS (1 - V)2; P P Both devices do not satisfy the function of homogeneity, so they are non-linear. BASIC ELECTRONICS 1-16 Chapter 1: STUDY ON BIPOLO TRIPOLO AND QUADRIPOL BELOW we will show a few examples of nonlineary devices with their V-A characteristics, including a nonlinea chain consisting of incandescent bulbs powered by a source of AC voltage. Fig. 1.13 - Examples of nonlineary devices and circuits and their V-A characteristics: (a) is a digital buffer; (b) Is a permanent win-win amplifier between E1 and E2; With a saturated output (limited) to the left of E1 and to the right of E2; (c) Is the port of inverter logic; (d) An incandescent lamp operating at variable voltage. 1.11.5 LINEING BY PARTS A chain may not be linear in the domain and be in some subdomains. If this does not happen throughout the domain, we will check the principle of withdrawal of the derivative in relation to the input. Be the S outlet and the E input such that S'f (E). If dS/dE-CTE (positive value is permanent, negative or zero) in some Subdomene E, then the diagram is linear in this subdomene. If it's nonlineous, it can be linear in parts. However, if the circuit is linear in only one subdomene, we say that it is partially linear; if it's linear in some sub-domen, we say it's linear in parts. We can decommitE S and E in its CC and AC components: S sCC and sCA and therefore E - ECC and eCA. In any subdomene where the circuit is linear, we can create a new pair of axes, starting at one point (SCC, for sCA and eCA variables. Then, in this subdomene, sCA q f (eCA) satisfies the properties of aditiality and homogeneity. Linearity in parts of the graphical characteristic means dividing it into regions and bringing it together by direct segments. The best part of linearity will be done by additional segments of lines. It is not always practical, preferably. In rice. 1.13 NELSON JOSE CAMELO - DEE-UFMA 1-17 NELSON JOSE CAMELO - DEE-UFMA We show how linear chicken is between the points of Operation A, B; e, B and C. Visually we noticed that the direct segment between A and B pic. 1.13 (a) is closer to the chicken dots than rice. 12.13 (b). In the case of fig. (b) the rectilinean segment, traced between the two points between B and C, is closer to the curvature than in the case of Fig. (a) with a line between B and C. This type of linearity is called point by point because it is drawn, taking as a reference at least two points of each area, pic. Another type of linearity is tangent, which consists of approaching the curvy tangent segments, as shown in the pic. 14. In this type of linearity called tangent linearity, we use only one curved point as a reference for each approximation. (a) (h) (b) (c) (e) pic. 13 - Line-to-point. (a) (f b) rice. 1.14 - Tangential Linearity. BASIC ELECTRONICS 1-18 Chapter 1: STUDY ON BIPOLO TRIPOLO AND QUADRIPOLO 1.11.6 STATIC RESISTANCE We assume a bisexual, V-A characteristic of which is shown in rice. 1.15, and which works in static conditions, i.e. constant current and voltage, ICC and VCC. The point defined by these coordinates is defined as a quiet point of operations, then q (Icc, VCC). At the moment we define static resistance, or RCC, as follows: R CC and VCC (1.47) ICC Fig. 1.15 - a) Nonlineary V-A characteristic and operating point; (b) The static resistance associated with the RCC point is that at the point of operation, the device can be replaced by an RCC resistance resister without changing the values of terminal variables, ICC and VCC. 1.11.7 MEDIUM CA RESISTANCE We assume that the bipolis, whose V-A characteristic is shown in the pic. 1.16, and which works in dynamic conditions, that is, with current and voltage from IC1 to IC2, and VC1 to VC2 around the operating point of the C. Therefore, the bipol works in the curved segment from q1 to q2. Fig. 1.16 - (a) Static operating point; (b) Dynamic operation area from 1 to 2 euros. NELSON JOSE CAMELO - DEE-UFMA 1-19 NELSON JOSE CAMELO - DEE-UFMA This curvilin region has endless points, each with a different bias. Thus, with various related resistance. In the association to the chicken segment we will approach it on the rectilin segment, as shown in the pic. 1.17(a). Fig. 1.17 - a) linearity of the kurvilin segment from q1 to q2; (b) Extrapolation from linearity to i 0 A and v VC0. From rice. 1.17 (a) we define rm'dia (average resistance) by: rm'dia and VC2 CI2 0.1 points per point (q a q) 1 2 (1.47) Rectilinary segment shown in the pic. 1.17 (b) mathematically represented: v q VC0 and rm'dia i with v range from VC1 to VC2. (1.48) The practical meaning of rimidia is that non-linear bipol, rice. 1.17 (a) can be replaced by the bipolar connection described by Eq. (1.48), as shown in the pic. 1.18. Pic. 1.18 - Bipol linear compound equivalent to non-linear simple fig bipol 1.16a, operating in the region from q1 to q2. 1.11.8 DYNAMIC AC

RESISTANCE We assume the same bipolar, the V-A characteristic of which is shown in rice. 1.16, and which works in dynamic conditions, that is, with current and voltage from IC1 to IC2, and VC1 to VC2 around the operating point of the C. Therefore, the bipol works in the curved segment from q1 to q2. Now let's associate the resistance of the curvylinary segment, approaching it on the rectilineal segment, as shown in the pic. 1.19 (a). BASIC ELECTRONICS 1-20 Chapter 1: STUDY ON BIPOLO TRIPOLO AND quadRIPOLO Fig. 19 - (a) The linearity of the curvature segment from q1 to q2 linear tangent segment to the point of operation; (b) Extrapolation from linearity to i 0 A and v VC0. From rice. 1.19a we define rd (dynamic resistance) by: rm'dia and dv di at the point of operation q (1.49) Rectilinary segment shown in the pic. 1.1b, mathematically represented: v q VC0 and rd i with v range from VC1 to VC2. (1.50) The practical value of rd is that of non-linear bipolis, rice. 1.19a, can be replaced by a bipolar connection described by Eq. (1.50), as shown in the pic. 1.20. If we know the i q f(v) function, just calculate its derivative at the point of Z. We don't need a graph. Fig. 1.20 - Bipol linear compound equivalent to non-linear simple fig bipoly 1.19a, operating in the region from q1 to q2. COMMENTS on CA's medium and dynamic resistance: a) Let's keep the concept of dynamic resistance, rd, for incremental segments of linearity, that is, around the point of view. (b) For broad linearity segments, we associate the concept of medium dynamic resistance, rmed, or sometimes denoted rf. In this case, we will be strictly concerned not with the extreme points of intersection, but with a more practical approach to the region. The related segment is also not necessary go through two dots, as in the example on the right, between A and B, as in the case of rice. NELSON JOSE CAMELO - DEE-UFMA 1-21 NELSON JOS' CAMELO - DEE-UFMA 1.13b, taking the curvilina region by direct incident of the site with the axis of variable v. This is much more justified because vertical measurement i, at point B, is considered insignificant value. COMMENTS on linearity by piece: The linearity done point by point may have an average resistance equal to the dynamics (which will be obtained by tangent to the point of operation), as shown in the pic. 1.21. We observed in the picture on the right that when a small segment was made point by point or on a tangent, the average AC resistance approaches the dynamics, i.e. rmed 🖉 rd. Usually, when a dynamic operation is injected with small signals, we work with dynamic drag, rd, especially when it can be obtained by calculating the derivative of the characteristic function of the device at point q of the operation area. In this case, chain analysis is called small signal analysis. Fig. 1.21 - That is, tangential and tangential linearity. 1.12 CIRCUIT MODELS FOR A BIPOLO We have simple and composite bipoli. A composite bipolis is an open circuit formed from simple elements in a series or in parallel. An example of a simple bipolar: a resistor; Consider the two-field chain represented by rice. 1.22 with p1 and p2 poles, respectively. We imagine the potential difference between the poles just v1. Thus, v1 (vP1-vP2). the i1 represents a current that enters the p1 pole and goes to p2. v1 and i1 are called voltage and input tone respectively. These are the terminal variables of the bipolar. Fig. 1.22 - Representation of the bipol in the block with poles p1 and p2. For this bipolo we can write two functions, establishing the relationship between terminal variables i1 and v1: BASIC ELECTRONICS 1-22 Chapter 1: STUDY ON BIPOLO TRIPOLO AND QUADRIPOLO i1 - f (v1.ix) are conductivity parameters (unit S - Siemens) and resistance (unit - ohm), respectively. The questions are ' are dimensional parameters. Any of these features describes the relationship between current and voltage in the two-field terminals. In rice. 1.23 We show the performance of the function (1.51). In rice. 1.24 We show the performance of the function (1.52). Fig. 1.23 - Circuit model for i1 and f (v1,ix), and can be called an equivalent chain norton. Fig. 1.24 - Circuit model for v1 and g(i1,vx), and can be called equivalent district Thievenin. In an open chain of rice. 23, if No 0, the bipol becomes a representation of a simple element of the chain - the resistor. The same Figs. 1.24 if - 0 euros. On the other hand, if we call qix iNo (Tok Norton), the bifield configuration of Fig. 23 involves the representation of the Norton equivalent chain. If ix represents a current on any pair of nodes, another element, or a chain block, the branch to the right of G represents the current-controlled current source. In this case we say that bipol rice. 1.23 is a chain model for a real current current-controlled current, with a several resistance of 1/G. Similarly, if we call it vx vTh, the bipolar configuration fig. 1.24 involves the representation of the equivalent Th'venin chain (vTh - Th'venin voltage). If vx represents the voltage on any pair of nodes of another element or circuit block, the R NELSON JOS' CAMELO series is a voltage-controlled voltage. In this case, we say that bipolar is rice. 1.24 is a chain model for a real voltage-controlled voltage source, with the release of R resistance. Other possible models for bipole figs. 1.22: i1 - f (v1, ix) - G1v1 - qix (53) i1 and f (v1, ix) - G1v1 - Gxvx (54) v1 (g(i1,vx) - R1i1 - Rxix (55) v1 (i1,vx) - R1i1 - vx (56) Relationships (1.53 to (1.6) can take on other formats, if we replace G and R. These functions correspond to mathematical models of bipoles, representing real sources of current and voltage controlled by voltage and current, respectively. This idea leads to the study of the quadripolis from its terminal variables, i1, v1, i2 and v2. 1.13 QUADRIPOLES AND TRIPLO CIRCUIT MODELS Consider the quadriduly of its terminal variables, i1, v1, i2 and v2. 1.13 QUADRIPOLES AND TRIPAL CIRCUIT MODELS Consider the quadrangle scheme presented by the pic. 1.25. v1 and i1 are terminal variables of p1 and p2 poles. v2 and i2 are the terminal variables of the p3 and p4 poles. v1 (vP1-vP2); v2 (vP3- vP4). It should be noted that in each pair of poles were selected related directions of current and voltage. A pair of p1 and p2 poles is called the entrance port. A pair of p3 and p4 poles is called a weekend port. Fig. 1.25 - Representation of the quadripolis (fields p1, p2, p3 and p4). Taking the v1 input variable and the i2 output variable as an independent, we can write the following functions for this quadripolis: v1 g (i1,v2) - R1i1 - v2 (1.57) i2, G (i1,v2) R1, G2, No and W: BASIC ELECTRONICS 1-24 Chapter 1: ON STUDY BIPOLO TRIPOLO AND QUADRIPOL V1 R1 : input Exit; (R1) ; i1 v No0 v 2 v 2: Reverse voltage transfer factor in open circuit at the entrance; i1 No.0 A-Yamer; i and i2 1: Direct current transmission ratio at short-circuit exit; v2 No 0 V and size; i G2 and v1 2 i1 No0 A : holding an open circuit at the entrance; S. In the pic. 1.26 We show performance (1.57) and (1.58): pic. 1.26 - a quadrangle scheme to hybrid parameters. Next, we rewrite features (1.57) and (1.58) in their usual form: v1 g (i1,v2) - h11i11 h12v2 (1.59) i2 i1 v No 0 v 2 i h21 1 in adimensional v2 No0 v v h12 - v1 2 adimensional i1 No0 A i h22 and G2 - v1 2 in S i1 No0 Odds independent variables, h11 to h22 are called hybrid parameters, because they are expressed in different units. From this fact, we take the initial letter of the hybrid word to represent the parameters h. We can express hybrid parameters using partial derivatives as follows: NELSON JOSE CAMELO - DEE-UFMA 1-25 NELSON JOSE CAMELO - DEE-UFMA -- v h11 - 1 1 1 x2 1 th 'i2 1'v in h12 ' v1 adimensional h22 - v1 adimensional 2 'i 2 in S We can pull the tripole chain out of the quadrangle, Taking the pole for a common reference to the entry and exit as shown in the pic. 1.27. Pic. 1.27 - Tripole Hybrid Options Scheme. We can choose other pairs of independent variables and create new quadrangle models. The quadrangle chain fig. 1.26 is shaped like t-N (Tavenin-Norton). From this we can create three more equivalent settings: T-T, N-N and N-T, the task we leave to the reader. 1.14 BIPOLO VOLT-AMP FEATURES In the following pictures we show voltage and current sources. v - Vo to i (a) (b) Fig. 1.28 - Ideal voltage source: a) V-A feature; (b) The chain symbol. Mathematical model: v - Vo and Ri to Im - i - In (a) (b) Fig. 1.29 - Source of actual voltage: a) characteristic V-A; (b) The chain model. BASIC ELECTRONICS 1-26 Chapter 1: STUDY ON BIPOLO TRIPOLO AND QUADRIPOLO i - Io for q (a) (b) pic. 1.30 - Ideal current source: a) v-A feature; (b) The chain symbol. Mathematical model: i and Io v/R for Vm - v - Vn (a) (b) Fig. 1.31 - Real current source: a) V-A feature; (b) The chain model. Mathematical model: i qix q v/R for Vm - v - Vn (a) (b) Rice. 1.32 - Current controlled real current source: (a) V-A feature; (b) The chain model. Mathematical model: v qvx and iR for i - in (a) b) rice. 1.33- Voltage-controlled real voltage source: (a) V-A feature; (b) The chain model. NELSON JOSE CAMELO - DEE-UFMA 1-27 NELSON JOSE CAMELO - DEE-UFMA Tripole or quadripolis has entrance and weekend characteristics similar to those shown in Figure 1.28 to 1.33, because they consist of an entrance bifield and a weekend bifield, as shown in Figure 1.26 and 1.27. 1.15 SUMMARY1 In this block, we provide a complete picture of all the foundations needed for the development of subsequent blocks. The main electronic devices, diodes and transistors are non-linear in nature. A significant effort by the engineer is to ensure that electronic devices work in regions of their characteristics, which can be considered linear. Chains made with linear devices are also linear. Linear chain analysis is easier because it leads to system linear equations. To do this, you need to know how to use methods of linearity, modeling and analysis of circuits with diodes and transistors, fundamental elements of electronics. The simulation is done with bipolar, tripole and quadripolis, seen in this chapter as a whole. From electrical characteristics, usually V-A, we can write mathematical and circuit models. The concepts of linearity are fundamental in electronics and electrical engineering in general. 1.15 REFERENCE CONSULTED ELECTRONIC DEVICES AND chain theory; Robert L. Boylestad and Louis Nachelski; Pearson Prentice Hall, 8th edition. BASIC CHAIN THEORY; Charles A. Desoer and Ernest S. Ku; McGraw Hill, 1969. THE BASICS OF ELECTRICAL CIRCUITS; Charles C. Alexander and Matthew N. O. Sadiqu. 1 To improve this work, we ask readers to point out possible glitches and suggestions for improvement and other discussions. BASIC BASIC ELECTRONICS electronic devices floyd 9th edition solution manual pdf free download