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Loudness and Level Controls

The new line of C/COS ("Computer-Crafted") stereo tuners features a **Level Control** in addition to the familiar tone-compensated **Loudness Control.** Because the level control is new this year in RCA products, it should be of interest to the reader to learn the theory behind the level and loudness controls, and a method for adjustment.

The level control is an uncompensated volume control which is located between the audio preamplifier and the input of the power amplifier as illustrated in Figure 1 below.

The loudness control serves to compensate for a physiological phenomenon of the listener's ears that makes them less sensitive to low frequency sounds as the listening level is reduced. This accoustical property, known as the **Fletcher-Munson Effect,** makes it necessary to gradually boost bass as the listening level is reduced. Figure 2 indicates that little or no bass boost is required at high listening levels, and as the sound level is decreased from loud to soft, increasing amounts of bass boost must be supplied in order to reproduce the lower frequencies in balance with the mid frequency and high frequency sounds. This then is the function of a loudness control circuit, such as the one used in the new radio tuners.

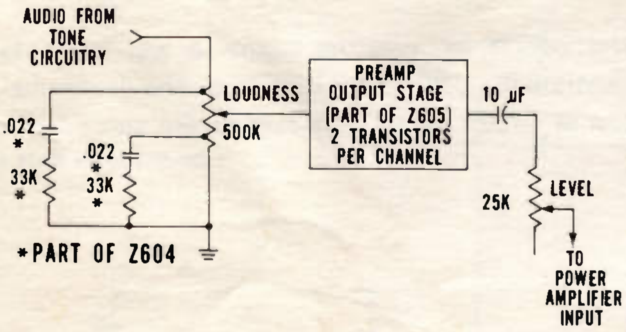


Figure 1—Simplified Loudness/Level Circuitry

Controls Adjustment

One adjustment procedure for level and loudness is to adjust the level control to maximum, and the loudness control to a comfortable listening level. If the sound seems to have excessive bass at this setting of the loudness control, the level control setting should be reduced, and the loudness control advanced until a pleasing tone balance is achieved.

Once the level control is set, the loudness control should be use to regulate the sound intensity, as it will retain tone balance of a fairly wide change in loudness.

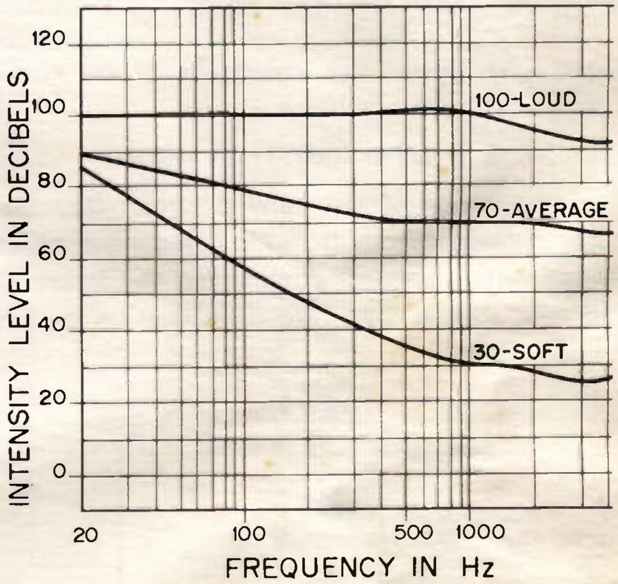
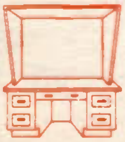


Figure 2—Loudness Compensation Curve



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More on Reactance and Impedance

The last issue of "Plain Talk and Technical Tips" contained a discussion of the properties of reactance and impedance in series R-L-C circuits. This time the text explores **parallel** AC circuits. To simplify the explanation, and allow comparison of the series and parallel circuits, the parallel examples herein use the same numerical values for R, X_L, and X_C.

The first circuit to be considered (Figure 3) is a resistance (R) of 20 ohms paralleled by a capacitive reactance (X_C) of 10 ohms. Assume it is necessary to calculate the input impedance (Z), input current (I_T), and the individual component currents((I_R and I_X). In this case, the current in resistor R, and capacitor X_C may be found by use of Ohm's Law. In the case of the capacitor, X_C is substituted for R in the I = E/R equation. Solving for both currents, indicates a value of 5A through the resistor, and 10A through the capacitor.

At first glance, the total current (I_T) would seem to be the sum of the component currents; but, this is not the case however. Remember that capacitive reactance causes a phase shift between voltage and current, so that the current leads the voltage by 90°. Therefore, it is not possible to add these currents arithmetically. Instead, these must be combined as indicated:

$$I_T = \sqrt{I^2_R + I^2_{XL}} = 11.2A$$

Once I_T is known, the impedance of the circuit may be calculated as below:

$$Z = E/I \text{ or } 100V/11.2A = 8.9\,\Omega$$

The impedance of the parallel circuit may also be calculated directly from the component values, obviating the steps of determining the individual currents, adding them, etc. This may be accomplished by using a formula similar to that used to calculate resistance of two paralleled resistors. Beginning with the general formula for parallel resistors, $R_T = \frac{r_1 \times r_2}{r_1 + r_2}$, where R_T is the total resistance represented by parallel resistors r_1 and r_2, the formula above is modified by substituting Z for R_T, R for r_1, and X_C for r_2. Then, considering phase-shift, a new equation results:

$$Z = \sqrt{\frac{R^2 \times X^2_C}{R^2 + X^2_C}} = \sqrt{\frac{20^2 \times 10^2}{20^2 + 10^2}} \text{ or }$$

$$\sqrt{\frac{400 \times 100}{400 + 100}} = \sqrt{80} = 8.9\,\Omega$$

The same conditions prevail in a parallel inductor-resistor circuit. Figure 4 illustrates a circuit consisting of 20 ohms resistance (R) paralleled by 30 ohms inductive reactance (X_L). Solving for impedance and input current by the methods previously described yields values of 5A resistive current (I_R) and 3.3A inductive current (I_{XL}). Input current and impedance are found to be 6A and 16.7 ohms—try it! As in the R-C circuit, the more direct method to solve for "Z" is by using the previously discussed parallel circuit formula.

The reader will recall from his study of series circuits, that when X_C and X_L are combined, as they are in Figure 8, the leading (X_C) and lagging (X_L), components (currents) will tend to cancel. The resulting input current (I_T) will appear either capacitive or inductive, depending upon the values of X_C and X_L.

The circuit example in Figure 8 will serve to illustrate the parallel R-L-C circuit. The determination of circuit parameters follows the same basic

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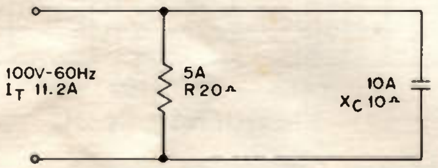

Figure 3—Capacitive Reactance

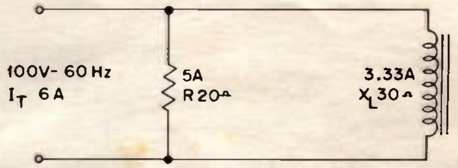

Figure 4—Inductive Reactance

Battery Recharge Circuit

The model YZS 545 five-inch reel-to-reel tape recorder features a **rechargeable** 9 volt battery supply. Thus, the instrument may be operated from either the 120 volts line, or the battery supply.

Six special "D" size alkaline cells (RCA-VS 1513) are series connected, comprising the 9 volt supply. These cells, when used under controlled conditions, may be recharged many times.

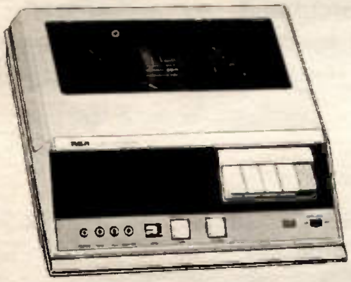

Figure 5—Model YZS 545 Tape Recorder

The transistorized recharge circuit provides the controlled recharging conditions necessary to effectively use the rechargeable alkaline cells in this tape recorder.

Although the alkaline battery pack should provide a number of discharge/charge cycles, the life of the battery is influenced by the way the battery is discharged and recharged.

The instruction manual furnished with the YZS 545 advises the user to subject the batteries to an over-night charge after every 2-4 hours of use. In addition the instrument includes a battery recharge light that serves to alert the user that it is time to recharge." Past this time, the recharge light will glow steadily when the instrument is on, indicating that the battery could be damaged if further discharged.

Recharging The Battery

The transistor recharge circuit illustrated in Figure 6 serves to provide the controlled recharging conditions required to assure maximum battery life. When the battery is to be recharged, the rectifier power supply in the instrument furnishes about 9 volts DC to the charge regulator transistor (Q10). Switching is provided so that one switch (Battery/AC-Recharge) selects battery or AC operation, and the other (Play/Stop-Recharge) allows the rectifier supply to power either the amplifier-motor or the recharge system.

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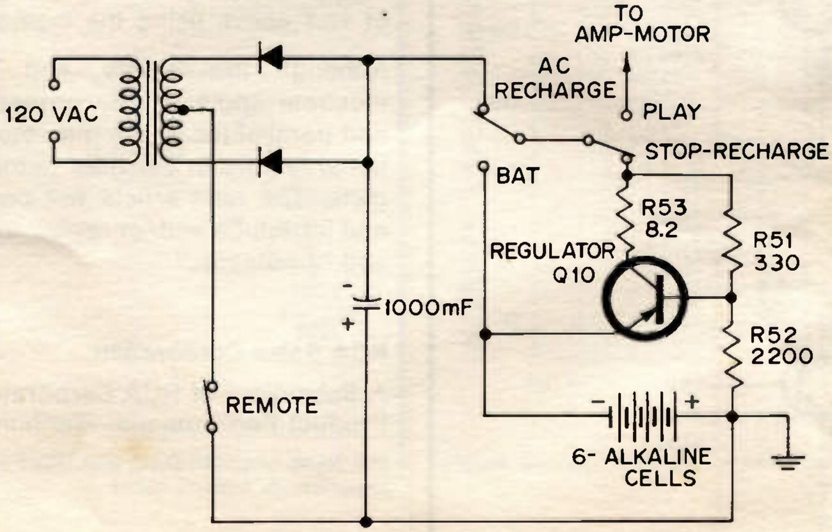

Figure 6—Battery Recharge Circuit (Simplified)

Battery Recharge Circuit

Continued from Page 3

The charge regulator is basically an emitter-follower in which the unity voltage gain characteristic is used to provide a current limiter circuit.

When the battery is discharged (Figure 7), its open-circuit terminal voltage will be about 7.3 volts. When then the recharge cycle is activated, the regulator circuit must supply a voltage that exceeds the battery voltage. Under these conditions the emitter voltage of Q10 and the battery assumes a voltage of about 7.7 volts. This causes the base voltage of Q10 to assume a value of 8.0 volts (emitter voltage +.3V base-emitter barrier voltage = 8.0V). Within the chosen values of R1 and R2 sufficient base current is supplied to drive Q10 into saturation, thus the resistance of the saturated transistor and the 8.2 ohm resistor (R3) limit the charging current to a safe value of about 130 mA.

As the battery charges, its terminal voltage (and Q10 emitter voltage) increases, and the charging current decreases until the charged condition illustrated in Figure 8 is reached. The battery/emitter voltage of 9.3 volts results in a base voltage of 9.6 volts, which is clamped at this point by the voltage divider action of R1 - R2. The reduced charging current (now 5 mA) allows the input voltage to the regulator to increase to 11.2 volts; however, the base of Q10 is clamped at 9.3 volts by R1-R2. Consequently, the base current diminishes, and transistor conduction is reduced until the conditions depicted in Figure 8 are satisfied. Thus the battery charge current, initially 130 mA, has tapered to 5 mA as the battery assumes full charge.

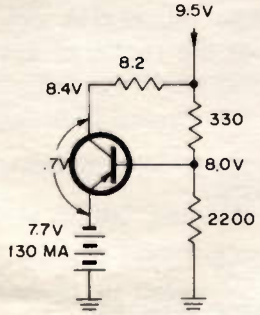

Figure 7—Battery Discharged

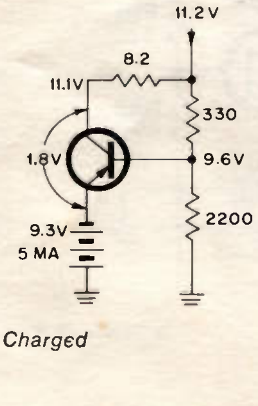

Figure 8—Battery Charged

It should be evident from this discussion, that the current regulator serves to protect both the alkaline battery and the rectifier power supply from the excessively high current that would result if the battery charge was not controlled by the current regulator circuit.

More on Reactance and Impedance

Continued from Page 2

procedure as the previous examples. Using Ohm's Law to derive the individual component currents, yields 5A through the capacitor, and 3.3A through the inductor. Solving for input current I_T—

$$I_T = \sqrt{I_R^2 + (I_{XC} - I_{XL})^2} \text{ or } I_T = \sqrt{5^2 + (10 - 3.33)^2}$$

—yields a current of 8.3A, which is substantially less than the numerical sum of the component currents. The resulting "Z" of circuit equals about 12.1 ohms, with the circuit appearing capacitive due to the larger X_C current.

The impedance of this circuit may also be directly calculated by substituting the term $(X_L - X_C)^2$ for X^2 in the parallel reactance equation. (The reader may wish to test his skill in mathematics by solving for the impedance "Z" of 12.1 ohms, using the method described.)

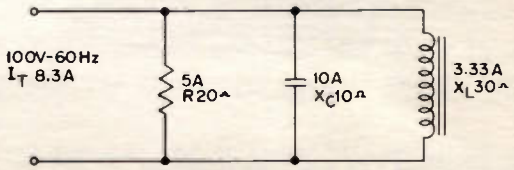

Figure 9—Combined Reactances

Although this article, and the previous one, illustrate some of the properties of both series and parallel R-L-C circuits, there are several additional factors to consider before the story is complete. The next article will consider phase-angle, and introduce and/or review the subject of vectors and "j notation."

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