HOW NEW FTC HI-FI RULES AFFECT YOU

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE NOVEMBER 1974/60¢

What's New in 1975 Color TV Receivers

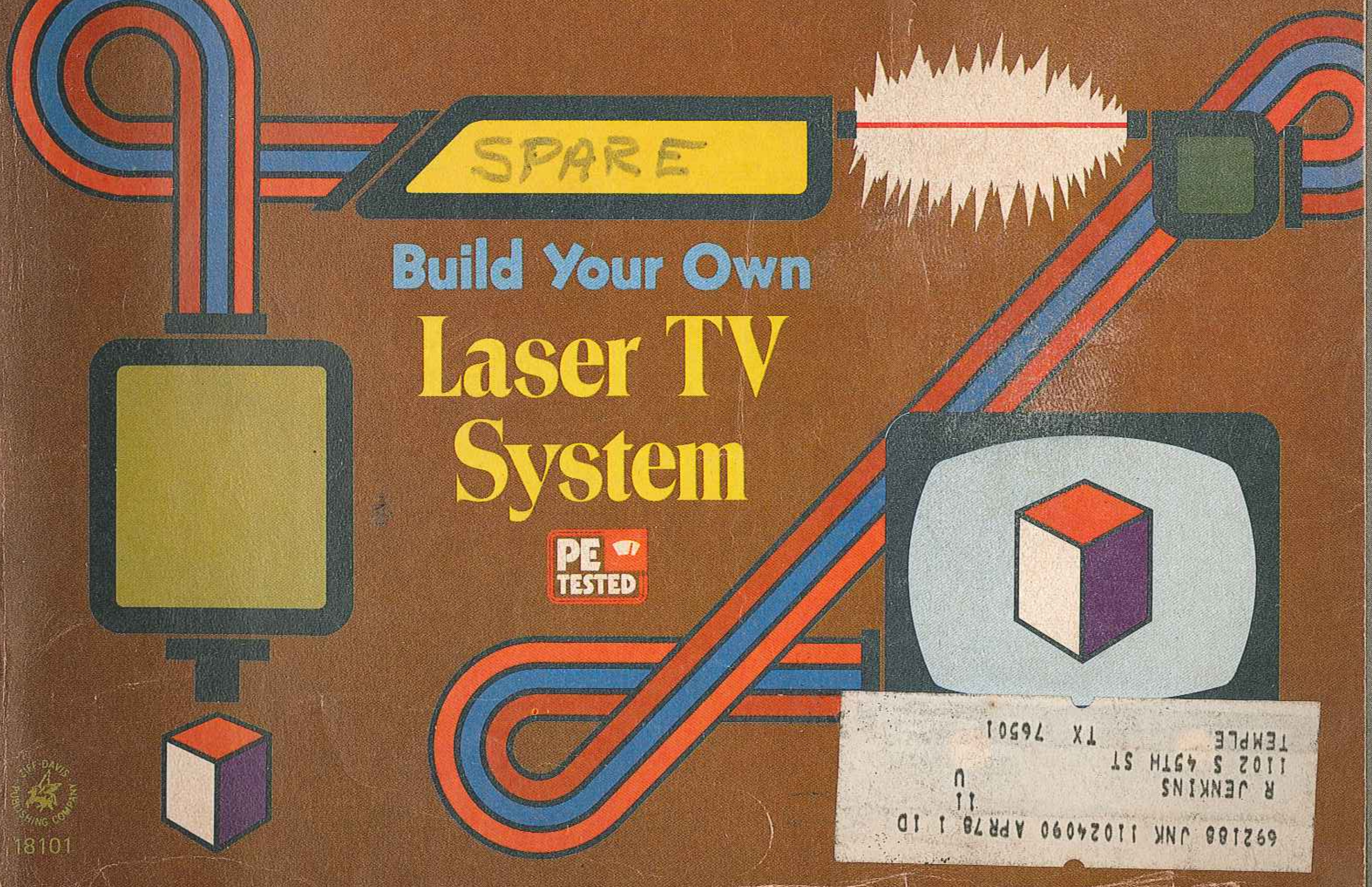
Build a Multimeter Range Extender

Career Opportunities for Tech Reps

A Direct-Conversion AM/SSB Project

Test Reports

Pioneer SX-636 Stereo Receiver
Pickering OA-3 Stereo Headphones
American Circuits & Systems MK1 Function Generator
Royce 1-600 CB Mobile Transceiver
Drake SPR-4 Communications Receiver



Build Your Own Laser TV System

PE TESTED

18101

Power Supplies. Three possible power supplies are shown in Fig. 2. Select the one that suits your needs. Any 5-volt supply that can deliver at least 300 mA can be used. If the digital thermometer is for fishing, use the ac-powered circuit. In this case, omit the transformer and diodes and use a battery holder to mount four 1.35-volt mercury cells, with an spst switch to control power.

Calibration. Connect the thermistor to *J1* and *J2* and apply power to the circuit. Allow it to warm up for at least 30 minutes. You will see a numerical display that will "blink" as the multivibrator operates every few seconds.

Fill a glass with ice cubes and top it off with cold water. Fill another glass with water that is as close to 90 degrees as possible. (Use an accurate mercury thermometer.) Set *R23* to its midpoint; and place the thermistor in the ice water *adjacent* to an ice cube. Without disturbing the glass or thermistor, adjust *R3* until the display indicates 33. Place the thermistor in the 90° water. If the display shows greater than 90, increase the value of *R2* until a reading of 90 is obtained. If the display indicates below 90, decrease the value of *R2*.

Insert the thermistor back in the ice water and touch up *R3* if the reading is less than 33. These adjustments will have to be repeated several times to get the readings as accurate as possible. If you encounter difficulty in attaining a linear display, adjust *R23*. In general, a decrease of resistance in *R23* results in an increase in sensitivity near the high end and a decrease in sensitivity at the low end.

Once calibration is complete, the digital thermometer should be within 1 degree between 0° and 90° F and usable between −50° and 130° F. Although this project was designed for the 0-90 range, it could be used to take readings of temperatures below zero and above 100° F. A reading of 90 on a bitter-cold winter day would mean that the true temperature is −(100-90) or −10°F. A display of 5 on a hot summer day means the temperature is 100 + 5 or 105° F.

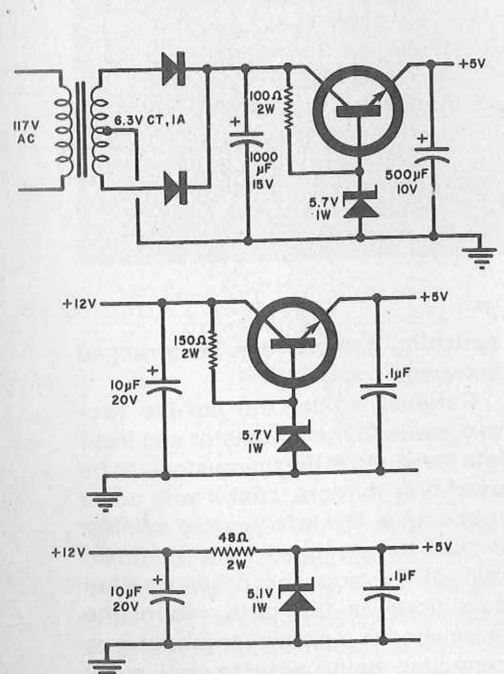


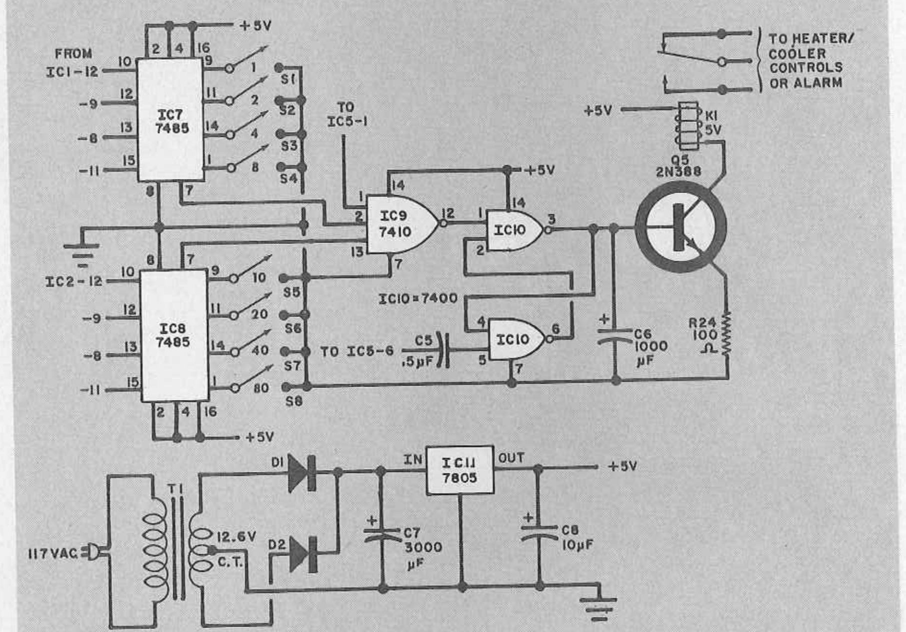
Fig. 2. Three typical power sources for thermometer. Top is for line power, other two are for mobile operation.

THERMOSTAT CONTROL MODIFICATION

You can convert the digital thermometer described in this article into a multipurpose heating/cooling thermostatic control with a 0° to 99° F temperature range by adding to it the circuit shown below. Relay *K1* and any alarm or circuit connected to it can be made to trip at any temperature selected by switches *S1* through *S8*.

The reference temperature selected by the switches is the sum of the closed-switch designations. For example, to set the system up for 34° F, you would close *S3, S5,* and *S6* (4° + 10° + 20° = 34°). If the sensed temperature falls below 34°, *K1* will sound an alarm or turn on the heat. Conversely, if the reference temperature is 99° and the sensed temperature rises to 101°, *K1* can sound a different type of alarm or turn on the cooling system.

The use of a 5-volt relay for *K1* and suitable connections for its contacts to the heating/cooling controls produces a state-of-the-art environmental control system that eliminates troublesome mechanical thermostats. For the most reliable thermostatic operation, increase the value of *C3* to at least 2000-µF and change the value of *R5* to 100,000 ohms. Also surround thermistor *TDR1* with ¼-in. (6.35 mm) of insulating material and protect it from drafts.



ADD-ON PARTS LIST

C5—0.5-µF disc capacitor
C6—1000-µF, 10-volt electrolytic capacitor
C7—3000-µF, 20-volt electrolytic capacitor
C8—10-µF, 15-volt electrolytic capacitor
D1,D2—1-ampere silicon diode (1N4001 or similar)
IC7,IC8—7485 magnitude comparator integrated circuit
IC9—7410 triple 3-input NAND integrated circuit
IC10—7400 quad 2-input NAND integrated circuit
IC11—7805 5-volt regulator integrated circuit
K1—5-volt relay with spdt contacts
Q5—2N388 (or similar) transistor
R24—100-ohm, ½-watt resistor
S1-S8—Spst switch
T1—12.6-volt, 1-ampere filament transformer

BY FORREST M. MIMS
AND H. EDWARD ROBERTS

BASIC DIGITAL LOGIC COURSE

PART 2: CONCEPTS AND CIRCUITS

IN PART 1 of our short course in digital logic, we discussed the binary number system, binary arithmetic, and the octal number system. In Part 2, we are concerned with logic concepts and circuits.

Boolean Logic. In 1847, George Boole, a British mathematician, published his *Mathematical Analysis of Logic.* This booklet did not equate mathematics with logic, but it did demonstrate how any logic statement can be analyzed with basic mathematical relationships. Boole published a much longer and refined version of his theory of logic in 1854. To this day, all practical digital computers and countless other electronic digital circuits are based on the concepts pioneered by Boole.

Boolean logic (or algebra) makes the important assumption that a logic statement is either true or false. Since electronic circuits can easily be made to operate in either of two states, on or off, it is convenient to equate "true" with "on" and "false" with "off." Similarly, we can equate the binary 1 with on and the binary 0 with off. With the foregoing in mind, let us review Boole's basic logic concepts.

The mathematical explanation of logic put forth by Boole can be simplified into three basic logic functions: AND, OR, and NOT. The AND function requires that one logic state or condition *and* at least one other be true before the entire statement is true. The OR function requires that one logic state *or* at least one other be true before the

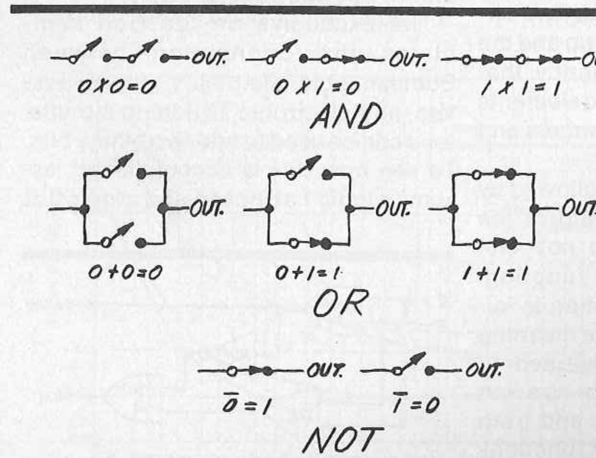


Fig. 1. Switches are arranged to illustrate three basic digital electronic functions.

entire statement is true. The NOT function simply reverses a stazement from true to false, or vice versa. Electronic NOT circuits are commonly referred to as "inverters" because their function is to invert the polarity of the signal.

The above definitions can be tabulated into a table such as shown in Fig. 1. Such a table is useful in showing the relationships among Boole's three logic functions and their electronic and arithmetic counterparts. This type of table is sometimes called a "truth table" since it sets forth the various logic conditions for which each statement is true. Generally, truth tables are arranged in a more compact form similar to those shown for the three basic logic functions in Fig. 2.

Truth tables can be created for *any* logic function. Specification sheets for digital logic circuits almost always include a truth table.

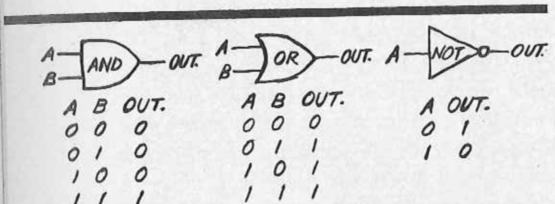


Fig. 2. AND, OR, and NOT symbols are shown with truth tables.

Logic Symbols. Boolean logic statements can be implemented by simply writing them on paper, using alphabetic symbols to correspond to "true" and "false" conditions. Electronic logic diagrams, however, are much easier to design and interpret if a sort of block diagram of the circuit is presented. For this reason, standardized logic-block symbols have been devised for the three basic logic functions. They are shown in Fig. 2.

Compound Logic Circuits. Two circuit combinations (the NOT-AND and the NOT-OR) are used so frequently that they are treated as basic logic elements and given their own logic symbols and truth tables.

When the AND function is followed by a NOT statement, the meaning of the AND function is reversed to NOT-AND, commonly called a NAND function. Similarly, when the OR function is followed by a NOT statement, the meaning of the OR statement is reversed to NOT-OR, commonly referred to as a NOR function. The logic symbols and truth tables for the NAND and NOR functions are shown in Fig. 3.

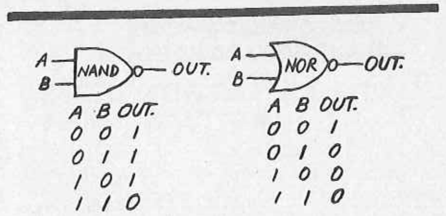


Fig. 3. NAND and NOR symbols with associated truth tables.

DeMorgan's Theorem. About the same time Boole developed his logic theories, Augustus DeMorgan was also developing some fundamental theories of logic. His most important contribution, known as DeMorgan's Theorem, relates the AND, OR, and NOT functions as follows:

$$\overline{A + B} = \overline{A} \times \overline{B}.$$
$$\overline{A \times B} = \overline{A} + \overline{B}.$$

The arithmetic symbols + and × mean OR and AND, respectively. The bar, or vinculum, over a letter indicates the NOT function. Thus $\overline{A}$ means NOT A.

The importance of DeMorgan's Theorem is that an AND circuit containing a NOT at each input corresponds to an OR circuit followed by a NOT. Similarly, an OR circuit with a NOT at each input corresponds to an AND circuit followed by a NOT. This does not equate the NAND and NOR functions, but it does mean that NAND circuits can be used to implement NOR functions, and vice versa.

Complex Logic Systems. Logic systems that contain three or more basic logic elements are termed "complex." One of the simplest of the complex logic systems is the EXCLUSIVE OR (sometimes written XOR) function shown diagramatically in Fig. 4. From the truth table, note that this function is identical to the OR function with one important exception: A true condition exists only when one *or* the other condition, but not both, is true.

The EXCLUSIVE OR function completes the connection between Boolean logic, the binary number system, and electronic switching circuits, for it can be used to add two binary bits. To see how this is accomplished, assume a logic 1 at input A and a logic 0 at

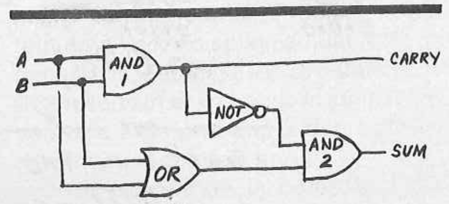


Fig. 4. Logic array for XOR circuit.

input B in the EXCLUSIVE OR circuit shown in Fig. 4. Since only one input is enabled (input A), AND circuit 1 does not turn on. Hence, a 0 is present at the CARRY output. OR circuit 1 does turn on, since only one input need be present. Since the NOT circuit inverts the 0 from AND circuit 1 into a logic 1, AND circuit 1 has two input signals and is therefore turned on. The result is a logic 1 at the SUM output. (The circuit has added 0 + 1 to obtain 1.)

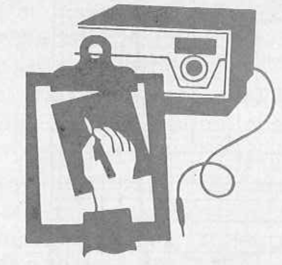
The EXCLUSIVE OR circuit is often called a "half-adder." Try verifying its operation yourself by adding 1 + 1 in binary.

Practical Logic Circuits. Figure 1 demonstrated how simple switching circuits can be used to implement each basic logic function. However, it is usually not practical to employ switches in real systems. Instead, transistors, SCR's, tunnel diodes, or other solid-state switches are employed.

The most commonly used switch in digital electronics is the transistor. Relatively simple circuits that combine diodes, resistors, and transistors can be used to implement the AND, OR, and NOT functions. Thanks to integrated circuit (IC) technology, several or even dozens of individual logic circuits can be placed on a single compact silicon chip. Resistor-transistor logic (RTL) was once the most popular type of digital IC, but it has been largely replaced by the more noise-immune transistor-transistor logic (TTL) type.

In recent years, field-effect transistor (FET) technology has been adapted to integrated logic circuits of amazing complexity. By insulating the gate of a FET with a layer of silicon dioxide, extremely high impedances are made possible. The result is a logic circuit that requires microamperes or nanoamperes of operating current at relatively low voltages.

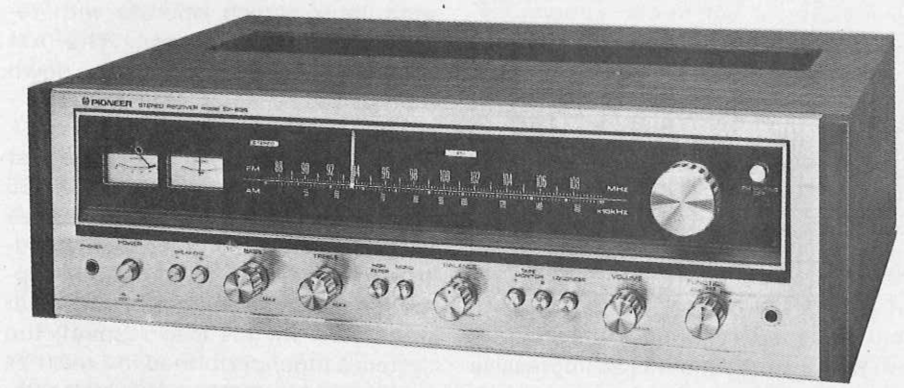
Insulated-gate fabrication techniques are collectively known as MOS (for metal oxide semiconductor) technology. Since MOS transistors are unipolar (p- or n-type) and do not require separate p and n sections like conventional bipolar pnp and npn transistors, MOS IC's can have a much higher component density than most conventional IC's. The result is large-scale integration (LSI). So, the next time you read or hear the phrase "MOS LSI," you will know that it refers to a large-scale integrated circuit employing metal oxide semiconductors. ◈



Product Test Reports

PIONEER MODEL SX-636 AM/STEREO FM RECEIVER
(A Hirsch-Houck Labs Report)

25-watts/channel receiver with superlative stereo FM tuner section



ROUGHLY in the middle of the current line of stereo receivers from Pioneer, the Model SX-636 features a tuner section that makes the most effective use of integrated circuit technology that we have yet seen in a hi-fi component. The result is a level of performance, in a moderate-priced receiver, that in some respects surpasses that of most separate components—to say nothing of far more expensive receivers.

The receiver's audio amplifiers are rated at 25 watts/channel over the entire audio range, with less than 0.5 percent THD. They are operated from balanced positive and negative power supplies and are direct-coupled to the speakers. The preamplifier section features tone controls with 11 lightly detented click-stop settings, and a balance control with a detented center setting. The phono preamplifier, whose gain allows the rated output to be developed with only a 2.5-mV input, can handle signals greater than 100 mV in amplitude without distortion.

The FM tuner section employs a fairly conventional front end containing a FET r-f amplifier followed by a dual ceramic i-f filter featuring linear phase characteristics. All other FM functions are performed by a single large-scale integrated (LSI) circuit—a proprietary development of Pioneer, containing circuitry that provides i-f amplification, five stages of limiting, and FM (apparently quadrature) detection. The detected signal then goes to a phase-locked loop IC for multiplex demodulation. The entire AM tuner consists of only one IC, plus a handful of external components. Consequently, Pioneer has made an AM/FM tuner with only three IC's and a relatively small number of discrete components, the performance of which proved quite exceptional in our laboratory tests.

The receiver has two pushbutton switches labelled TAPE MONITOR that allow two tape decks to be used simultaneously, with off-the-tape monitoring from either deck and the ability to copy tapes from one deck to the other. The FUNCTION switch has a PHONO/MIC position, in addition to the usual AM, FM, and AUX positions. Plugging a microphone into its jack automatically disconnects the phono pickup and applies a monophonic microphone signal to the preamplifiers of both channels. Another pushbutton switch is for the high-cut filter. And for maximum convenience, there are two ac outlets on the rear apron, one of which is switched.

The Pioneer Model SX-636 AM/stereo FM receiver comes complete with a walnut-finished cabinet for a fair-trade retail price of $349.95.

Laboratory Measurements. The audio amplifiers of the Model SX-636 receiver clipped at 29.7 watts/channel with both channels driven simultaneously at 1000 Hz into 8-ohm loads. Into 4 ohms, the power was 36.7 watts, while into 16 ohms, it was 20.5 watts/channel. The 1000-Hz THD was less than 0.1 percent from 0.1 to 30 watts, typically measuring less than 0.03 percent. The IM distortion was also less than 0.1 percent from 25 watts all the way down to less than 5 mW output.

At the rated 25-watt output level, and at one-half and one-tenth of rated power, the distortion was typically 0.025 percent or less over most of the audio-frequency range. It never exceeded 0.055 percent, this at full power and 20,000 Hz. At normal listening levels, the THD was about 0.01 percent. Our figures were a great deal better than Pioneer's *very* conservative 0.5-percent published figure.

A 10-watt reference output level was obtained with an input of 75 mV (AUX), 1.25 mV (PHONO), and 3.6 mV (MIC). The respective hum and noise levels were −81 dB, −75 dB, and −61 dB. The PHONO inputs overloaded with a 100-mV input, and the MIC input overloaded with a 275-mV input.

The bass tone controls had a sliding