AUDIO FREQUENCY RESPONSE METER

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Instruments for measuring frequency response have traditionally been complex and expensive. Here's an easy-to-use one that you can build for less than $25.

IT'S FREQUENTLY USEFUL—OR necessary—to know the frequency-response characteristics of audio equipment. This device will allow you to make accurate measurements of your amplifiers, tape recorders, and other audio and test equipment.

The instrument is most useful for "peaking up" tape recorders for optimum performance. It will permit you to measure the frequency response obtained with various brands of tape on your recorder and that, in turn, will make it possible for you to set the bias and equilization controls more accurately. If your tape heads become dirty or worn, the frequency-response meter will advise you of the fact long before you start noticing that your recordings do not sound right.

How it works

A block diagram of the device is shown in Fig. 1. The oscillator produces a constant-amplitude sinewave signal that's fed through a buffer/amplifier to the device being tested—a tape recorder, for example. The output signal from the device under test is fed back to the test unit, through another buffer/amplifier, and then to a meter calibrated in decibels (dB).

An 8038 voltage-controlled-oscillator IC generates the sinewave, which has about 1% distortion. That means that harmonics will be about 40-dB down, which is quite acceptable for our purposes.

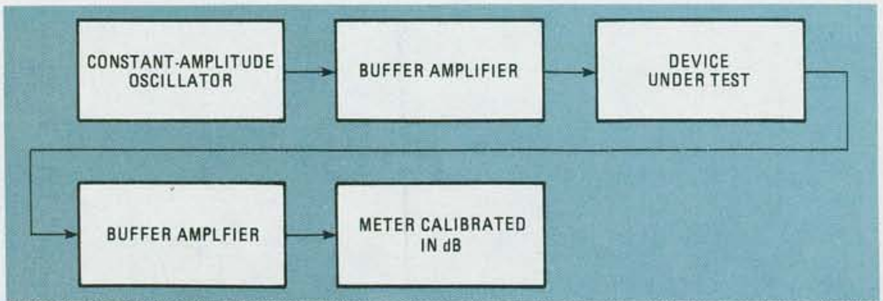


FIG. 1—FREQUENCY-RESPONSE METER outputs a tone to the device under test, and then displays the relative level of the same signal as output by that device.

Circuit description

Figure 2 is a schematic of the frequency-response meter. Resistor R2 is a potentiometer that functions as the (fine) frequency control. It varies the frequency over a decade (a factor of 10). Proper selection of R1 and R3 would allow R2 to give a three-decade change in frequency. That, however, would cause the dial markings to be so close together that it would be impossible to read the frequency with reasonable accuracy. Therefore, the frequency decades are selected by S1, which switches either capacitor C1, C2, or C3 into the circuit. Those capacitors should have a 2% tolerance, or should be trimmed as described in the "Adjustments" section.

Resistors R5 and R7 are used to adjust the waveform symmetry and to set the frequency of the oscillator, and resistors R4 and R6 protect the 8038 from damage that might be caused by extreme settings of R5 and R7. Resistor R8 is used to adjust the oscillator for minimum sinewave-distortion.

The input buffer/amplifier is IC2, a 741 op-amp that supplies a signal whose level is high enough to drive most of the devices likely to be tested. As configured, it provides a signal whose level can be varied from a few millivolts to 3 volts peak-to-peak. Short circuiting the output will cause no problem because of the presence of R11.

The output buffer/amplifier, IC3, is another 741 whose input is the output of the device being tested. Capacitor C5 blocks any DC signal-component that may be present. Diodes D1 and D2 protect the op-amp from overstrong input signals. Resistor R14 is used to set the meter to 0 dB at the 1-kHz reference frequency so that deviations from that level can be measured. The meter accepts an AC signal and gives a reading calibrated in dB.

PARTS LIST

All resistors ¼-watt, 5% unless otherwise specified
R1—33 ohms
R2—5000 ohms, potentiometer, linear taper
R3—30,000 ohms
R4, R6—2000 ohms
R5, R7—20,000 ohms, trimmer potentiometer
R8—100,000 ohms, trimmer potentiometer
R9—100,000 ohms
R10—220,000 ohms
R11—2200 ohms
R12—1000 ohms, potentiometer, log taper
R13, R16—10,000 ohms
R15—91,000 ohms

Capacitors
C1—0.12μF, 2%
C2—0.012μF, 2%
C3—0.0012μF, 2%
C4—0.47μF
C5—1.5μF
C6, C7—100μF (optional)

Semiconductors
IC1—8038 variable frequency oscillator
IC2, IC3—741 op-amp
D1–D8—1N914
M1—audio VU meter calibrated in dB. 1-volt RMS (or less) full scale, 2000 ohms (or greater) coil resistance
S1—SP3T rotary
J1, J2—RCA phono jack

Miscellaneous: power supply (±15 volts, 40 mA, 1% or better regulation), construction board, enclosure, hardware, etc.

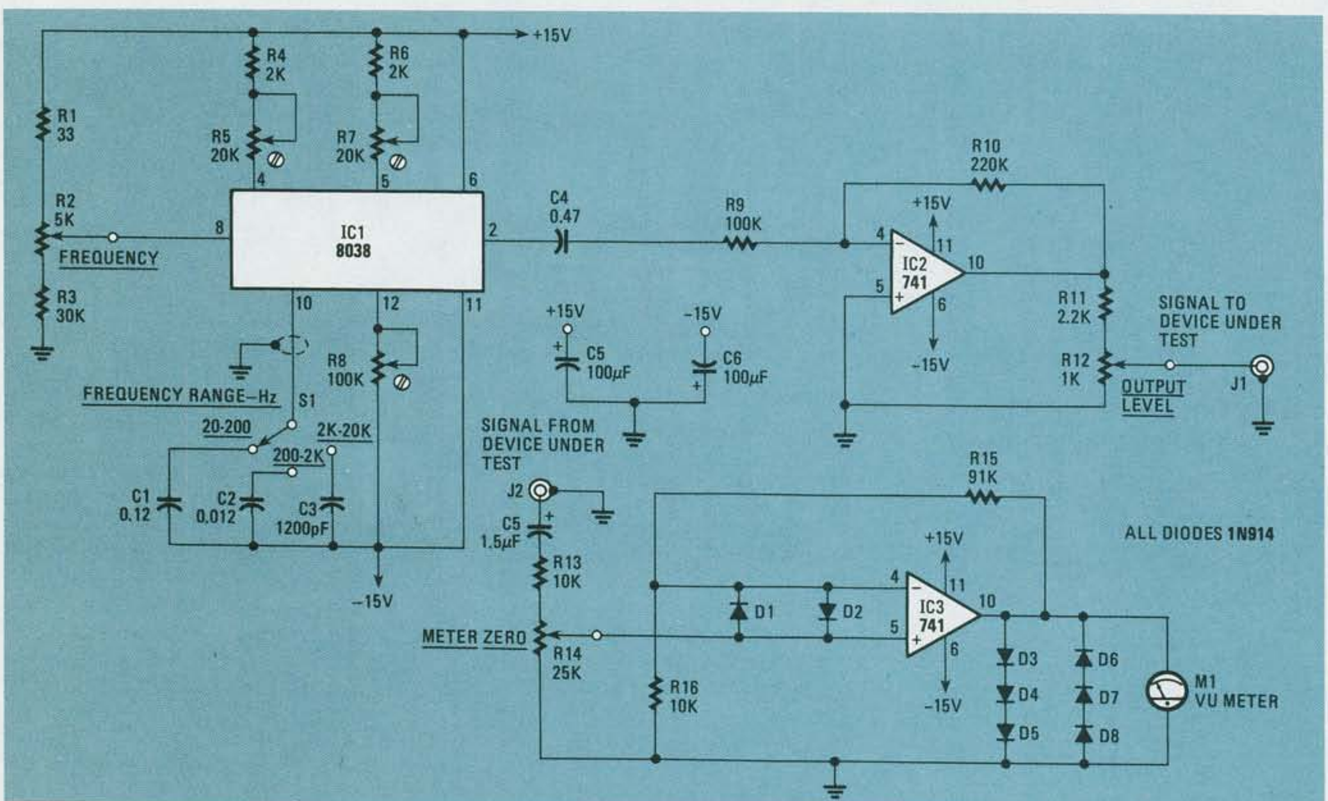


FIG. 2—CAPACITORS C1–C3 are switched by S1 to change frequency ranges. Their values must be accurately matched.

Diodes D3 through D8 protect the meter from being "pegged" with excess force.

The power supply is not shown, but any supply capable of delivering ±15 volts at 40 mA, with 1% or better regulation, will suffice. Good regulation is a necessity because voltage fluctuations will affect the accuracy of the frequency calibration.

Construction

Figure 3 shows how the front panel was laid out. The prototype was built in a 4½ × 4½ × 10-inch metal box, but a variety of boxes and cabinets are available and can be used. An attractive cabinet that can be displayed with your stereo equipment should be considered.

The circuit can be built on a variety of board types. The most common and easy to find are those which hold 0.1-inch spacing DIP (*D*ual-*I*n-*L*ine) packages. Just make sure that the board is large enough to hold the three IC's, two trimmer potentiometers, and the other components. Wire wrap or point-to-point wiring techniques are acceptable; the prototype used point-to-point wiring, as can be seen in Fig. 4.

A 22-pin connector was used to connect the front panel to the circuit board. That probably represents an unnecessary expense, as there are only five wires to connect to the panel and three to the power supply.

Figure 5 shows the component layout on the circuit board and on the front panel. Wiring to the 8038 is not critical unless you want to add another range to go above 20 kHz. In that case, the leads from pin 10 of the IC must be kept as short as possible.

If your power supply is more than a foot away from the rest of the circuitry, you should add a 100 μF capacitor from each power-supply line to ground at the circuitry (that's shown in the inset in Fig. 2).

Wiring to the 741 op-amps is not critical except for the wires attached to the inverting inputs (pin 4), which should be as short as possible. (That means that R9, R10, R15, R16, D1, and D2 should be within an inch of their respective IC's.)

Adjustments

If you have access to 1% or 2% capacitors, use them for C1, C2, and C3. However, precision capacitors are quite expensive. If you have a digital capacitance meter, you can use it to check lower-tolerance devices until you find values close to those required. You may have to add small capacitors in parallel to get the proper values. The exact values of C1–C3 are not important, since R5 and R7 are used to set the frequency. What *is* important is that the capacitor values be as close to exact multiples of each other as possible. For example, values of 0.15 μF, 0.015 μF, and 0.0015 μF (instead of the values shown in Fig. 2) would be quite acceptable.

FIG. 3—FRONT PANEL of author's prototype. Meters similar to the one shown are available from many of this magazine's advertisers.

If you do not have precision capacitors or a digital capacitance meter, all is not lost. All you have to do is measure the frequency of the oscillator as you switch from one range to another. If the frequencies are not exact multiples of each other, simply change (or make up parallel combinations of) capacitors until they are. The frequency measurements can be made using a digital frequency counter or an oscilloscope.

Adjust resistors R5 and R7 to obtain a symmetrical (i.e., not bent over to the side) sinewave of the proper frequency. To perform the adjustment, set R2 all the way counterclockwise. Set switch S1 to the 2KHZ–20KHZ position. Adjust R5 and R7 as many times as necessary until you get a symmetrical 2-kHz sinewave. (You'll find that each resistor seems to adjust half of the sinewave.) You'll need an oscilloscope (and ideally a digital frequency counter, as well) for that operation.

Resistor R8 should be set for minimum sinewave distortion. An oscilloscope is adequate for doing this, though a distortion analyzer would be better. If you're not sure of what to look for, compare the oscilloscope trace with a picture of an "ideal" sinewave in a magazine or book so you can recognize the proper shape.

The FREQUENCY potentiometer, R2, has to be calibrated and labeled. First, turn it completely counterclockwise. Then set the RANGE switch to the 2KHZ–20KHZ position. Verify that R5 and R7 are adjusted correctly by checking for a symmetrical 2-kHz sinewave at J1. Mark that position of the FREQUENCY control with a "2." Turn the control until your counter or oscilloscope indicates a signal with a frequency of 4 kHz. Mark the panel at that position with a "4." Perform similar calibrations for 7, 10, 14, 17, and 20 kHz, and mark the dial settings for frequencies between those points with dots. Finally, verify that the calibration is accurate on the other frequency ranges. (It should be if you chose your capacitors carefully.)

Operation

To measure the frequency response of a preamplifier or power amplifier, connect jack J1 of the response meter to the input

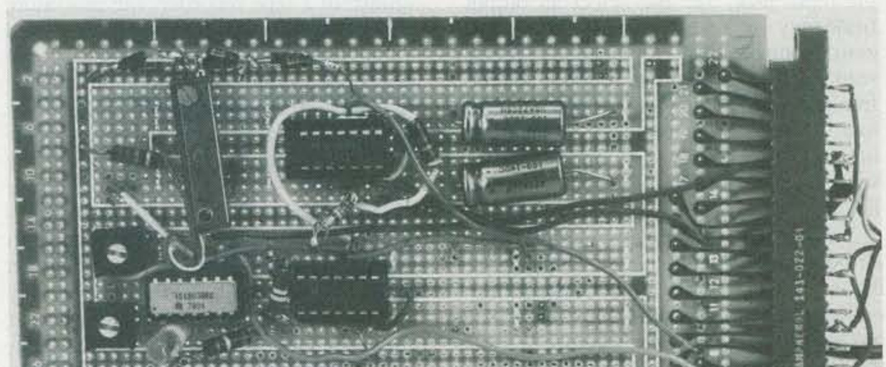


FIG. 4—ALMOST ANY TYPE of construction can be used. Leads of frequency-determining components should be kept short.

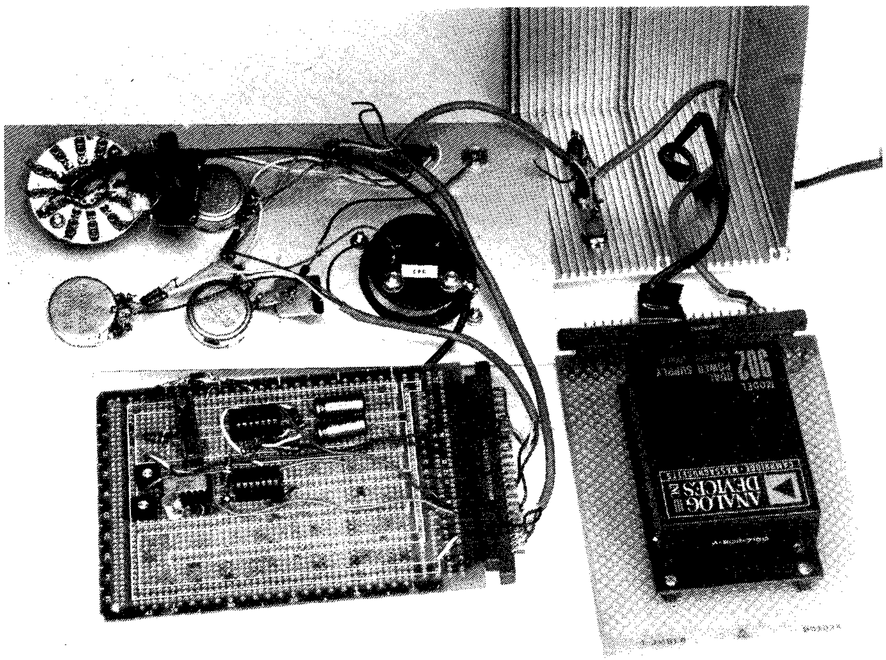


FIG. 5—REAR OF FRONT PANEL is seen above circuit board. Power-supply module is at right; it should be well regulated for accurate results.

jack of the amplifier. Adjust the output level control (R12) for a signal of the proper amplitude. That amplitude will depend on the signal requirements of the amplifier-input being used. If the amplifier being tested has built-in meters, they can be used to determine the proper amplitude. If there are no meters, you can listen to the signal through a speaker or earphones to verify that the level of the test signal is neither too high nor too low. A signal that's too high in level will sound distorted; one that's too low will be hard to hear and will sound noisy. Using an oscilloscope connected to the output of the amplifier is an excellent way to judge signal amplitude and distortion.

Connect the output of the amplifier to the input jack, J2, and select an output frequency of 1 kHz. Adjust the METER ZERO control, R14, to make the meter read 0 dB at that frequency. Then, set the frequency to 20 Hz and slowly start to increase it. At some point the meter reading will rise from −20 dB (which is where it will probably be at 20 Hz) and head up toward 0 dB.

You can note the frequency response at all points along the way, or simply note the −3-dB or −6-dB points, depending on your requirements. If your amplifier has a response that extends below 20 Hz, the meter will indicate it by starting out above the −20-dB point. You should sweep through the entire 20-Hz to 20-kHz range, noting the frequency response all the way up. The effects of tone controls and filters (scratch, rumble, and subsonic) on the overall response of the amplifier can be measured. A frequency-response test for each new switch setting can be run in about two minutes.

To check the operation of your frequency-response meter, connect its output to its input. You will, in effect, be measuring the frequency response of a piece of wire, the connecting cable. If there is any variation from a perfectly flat response, you should try to find out why. The most probable cause will be an inaccurate (non-linear) VU meter. A ±½-dB accuracy should be easily obtained. Good sources of VU meters are old stereo-equipment, surplus outlets, or parts catalogs; check the ads at the back of this magazine. A final word of advice: If you can see the pointer of the meter vibrating at frequencies below 30 Hz, don't be concerned—that's normal.

If you are measuring the frequency response of a tape recorder, the procedure will be slightly different from that used for an amplifier. If the recorder has three heads (i.e., separate record and playback heads), you can monitor the output from the tape and measure the overall record-playback response in pretty much the same way as you did for an amplifier. If the recorder has only two heads, however, the process will take a little longer. In that case you must record a tone of a given frequency, rewind the tape, and then play it back. If the recorder has a tape counter on it, you can record a series of frequencies and play them back all at once, using the counter to keep track of which frequency was where on the tape. Automatic-level controls must be turned off when you make your frequency-response measurements.

When measuring the high-frequency response of a tape recorder, do so at a level that measures about 12-dB below the maximum on the recorder's VU meter; otherwise you'll overload the recording circuitry. Recorders respond that way because normal speech and music contain relatively little high-frequency information, and the internal response curve of a recorder is such that it would be overloaded if a high-frequency signal at a level of 0 dB were applied to its input.

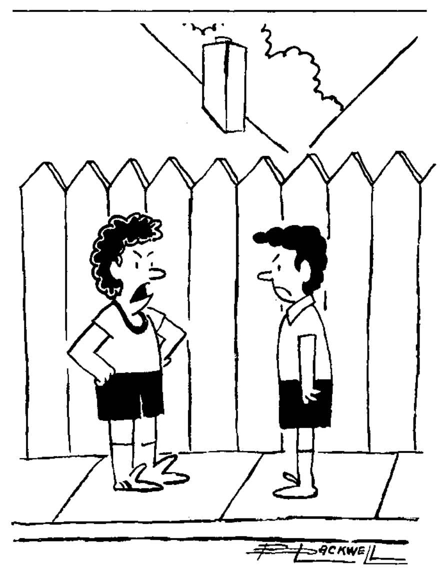
If a recorder has bias and equalization controls, you can use them to get the best possible response for a particular brand or type of tape. You should try several different ones to find which are best suited to it.

Modifications

The frequency range of the response meter's oscillator can be extended. With the selection of the appropriate capacitors, 1 Hz–20 Hz and 20 kHz–200 kHz ranges can be added. High values will produce low frequency ranges, and vice versa. A lower frequency-range will also require increases in the values of capacittors C4 and C5.

The triangle- and square-wave outputs of the 8038 can be made available as outputs on the front or side panel. The squarewave output of the IC can be used for risetime measurements, while the trianglewave is useful for slew rate measurements. It's a good idea to buffer those outputs the same way the sinewave output is buffered. Also, using the squarewave output of the 8038 often produces spikes in the sinewave input. If that happens, you may want to install a switch to disconnect the squarewave function when it is not in use.

The ability to measure frequency response is quite useful when choosing recording tape, checking recorder headwear, setting tone and filter controls, or adjusting a graphic equalizer. Most stereo components and audio test equipment can be evalutated in minutes with the use of the inexpensive instrument described here. **R-E**



"Oh, yeah? Well my *home computer can beat* your *home computer!"*