The Music-On-Hold Box

Endow your telephone with a feature usually reserved for more expensive phones at a fraction of the cost

BY MIKE GIAMPORTONE

Have you ever been involved in a phone conversation when halfway through a discussion, you needed to put someone on hold while you retrieve some important information for the other party? Or while in a telephone conversation, one of the children required your immediate attention? Covering the mouthpiece is not only inadequate and awkward, but it's also rude and does not prevent the other party from hearing what's going on at your end. And even if your phone provides a hold function, it is only humane to give the other person on the line something pleasant to hear, rather than dead silence.

Of course, one might feed local radio programming into the system for the party on hold to listen to, but some of the programming now traversing the airwaves can be more offensive to people than silence. The *Music-On-Hold Box* described in this article is designed for just such occasions. And the circuit, which can be built and installed in one evening (at a cost of less than $11), is easily added to an existing phone system.

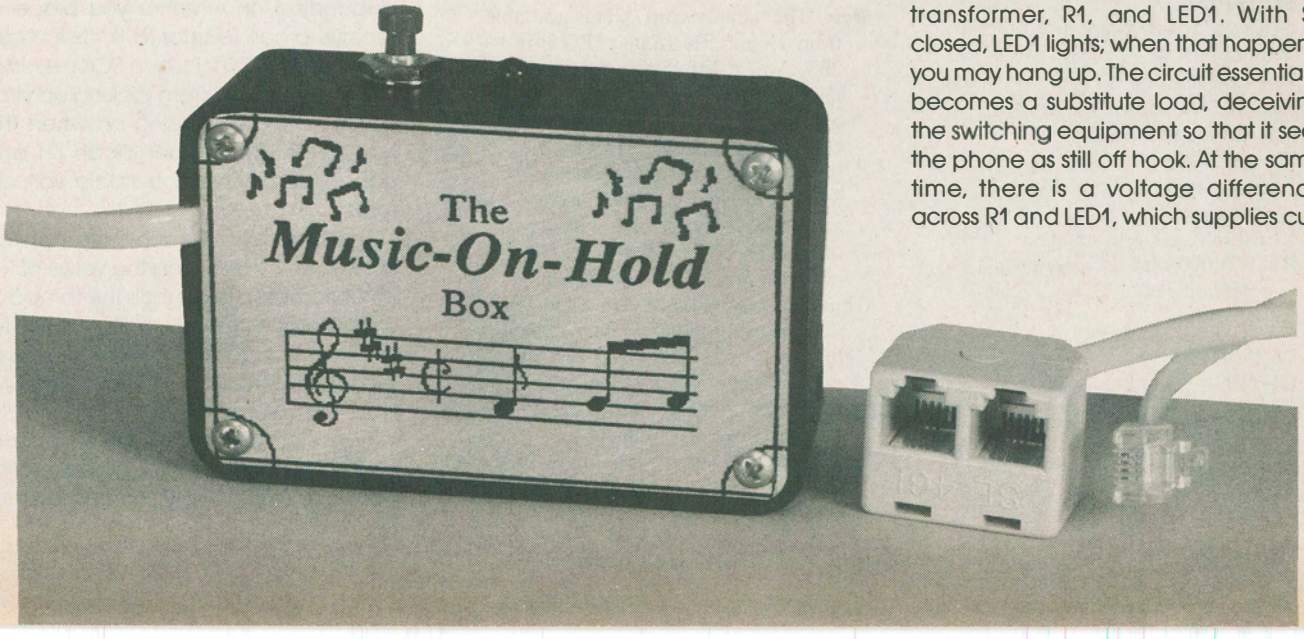
The Music-On-Hold Box is built around an LS3404 melody chip, manufactured by LSI Computer Systems, that is available in 31 versions, each containing a single tune or medley of tunes. The chips require few support components, and allows customizing of the tune/medley being played. Changing the song is as simple as plugging in the IC containing the new tune or medley.

Ease-of-Operation. The circuit is easy to install and operate. Once installed, all you have to do is press a button and hang up the handset to "pipe" music to the other party while he or she awaits your return. And if you have extension telephones connected to the same line, lifting one of the extensions (or the original phone) stops the circuit, allowing you to resume the conversation unimpeded.

The Music-On-Hold Box uses an LED to indicate the status of the call. If desired, the melody, tempo, or volume can be easily changed. In addition, the circuit—which is powered from the phone line so that it requires no external power source—does not load the phone line when it's not in use, so it's virtually undetectable. If desired, an optional transducer can be added to the circuit, so that you too can be entertained by the box's melodic output.

About the Circuit. Figure 1 is the schematic diagram of the Music-On-Hold Box. A normal one-party phone system uses only two wires—known as tip (which is the positive lead) and ring (the negative lead) in telephone tech talk—of the four supplied to each phone station. With the telephone handset on hook, there is approximately 48 volts DC (not to be confused with the 90-volt AC ring signal) across the green (tip) and red (ring) wires. When the telephone handset is taken off hook, a load is placed across the line, causing the DC voltage to drop to approximately 6 volts (depending on the subscriber's loop resistance and telephone).

Pressing S1 applies that DC voltage to the gate of SCR1, causing the SCR to turn on, which applies DC to the bottom of T1's 8-ohm winding and allows current to flow through the rectifier, transformer, R1, and LED1. With S1 closed, LED1 lights; when that happens, you may hang up. The circuit essentially becomes a substitute load, deceiving the switching equipment so that it sees the phone as still off hook. At the same time, there is a voltage difference across R1 and LED1, which supplies cur-



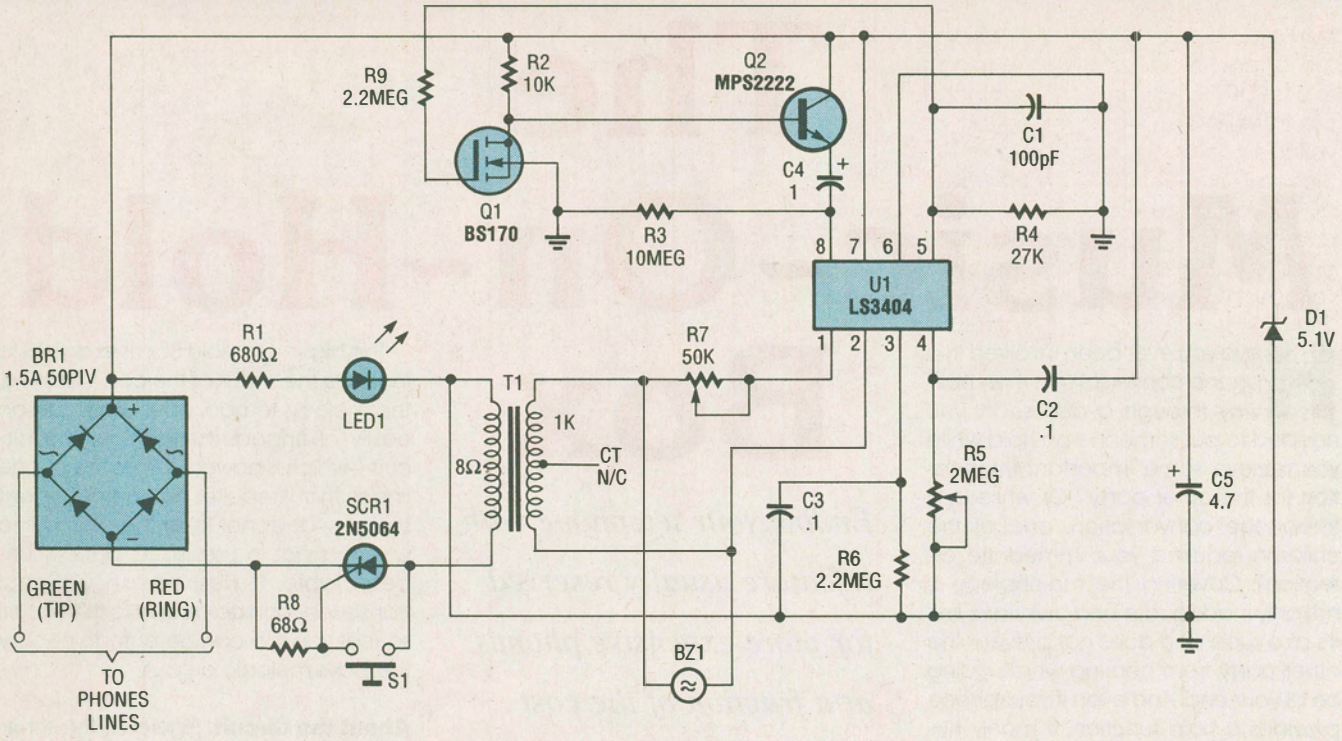


Fig. 1. The Music-On-Hold Box is built around a single-melody chip, which is supported by two transistors, an SCR, and a handful of additional components.

PARTS LIST FOR THE MUSIC-ON-HOLD BOX

SEMICONDUCTORS

U1—LS3404 melody chip, integrated circuit
Q1—BS170 N-channel MOSFET (Motorola)
Q2—MPS2222A or PN2222A general-purpose NPN silicon transistor
BR1—1.5-amp, 50-PIV full-wave bridge rectifier
SCR1—2N5064, 0.8-amp, 200-PIV silicon-controlled rectifier
D1—1N4733A or similar 5.1-PIV, 1-watt Zener diode
LED1—T-1-3/4, 2-volt, 20-mA, red diffused LED

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—680-ohm
R2—10,000-ohm
R3—10-megohm
R4—27,000-ohm
R5—2-megohm PC-mount potentiometer
R6, R9—2,200,000-ohm
R7—50,000-ohm PC-mount potentiometer
R8—68-ohm

CAPACITORS

C1—100-pF, ceramic-disc
C2, C3—0.1-μF, monolithic ceramic-disc
C4—1-μF, 35-WVDC, tantalum
C5—4.7-μF, 50-WVDC, radial-lead electrolytic

ADDITIONAL PARTS AND MATERIALS

T1—1000-ohm CT primary to 8-ohm secondary, audio-ouput transformer
S1—Normally-open, momentary pushbutton switch
BZ1—Piezo transducer, optional (see text)
Printed-circuit materials, enclosure, 8-pin DIP socket, LED holder, modular telephone cable and connectors (see text), wire tie, shrink tubing, wire, solder, hardware, etc.

Note: The melody chip (U1) is available from Thumb Electronics (PO Box 263, Avoca, MI 48006) for $2 each plus $1.50 shipping and handling per order. A 5-tune assortment of melody chips is available for $11, shipping included. Iron-on resist patterns for Music-On-Hold's printed-circuit board are available for $1 each with any order. The BS170 MOSFET (Q1) is available for $2 with any order. Thumb also sells the sheets for making your own iron-on patterns for labeling the cover or PC patterns. For a list of melodies in stock or technical assistance, send a self-addressed stamped envelope to the above address.

rent to the melody chip (U1), and in turn causes it to start playing back across T1. The melody is coupled to the phone line through T1, and transmitted to the receiver on the other end of the line.

When the handset is once again lifted off hook, most of the current flowing through the circuit is diverted to the phone. That drops the current through the SCR below I_H (the SCR's holding current), so the SCR ceases to conduct, thereby turning off U1.

The bridge rectifier (BR1) protects the circuit against polarity reversal when the circuit is connected to the telephone lines. The bridge rectifier is essential for older switching systems where the polarity of tip and ring invert, depending on whether you place or receive a call. Resistor R1 limits the current through LED1, T1, and SCR1. Resistor R8 prevents SCR1 from picking up stray voltages and remaining on when the handset is lifted. Zener diode D1 and capacitor C5, insure a stable voltage for U1.

The duration of each note can be shortened by reducing the value of R6. Potentiometer R5 controls the tempo or speed of the melody, while resistor R4 sets the pitch. Lowering R4's value raises the pitch of the tune. Potentiometer R7 limits the volume.

Transistors Q1 and Q2 (an N-channel MOSFET and a general-purpose NPN transistor, respectively) comprise a re-

start circuit, which resets U1 by inverting the voltage at pin 5 of U1 and feeding it to U1's POR (power-on-reset) terminal at pin 8. While the tune is playing, pin 5's voltage is applied to the gate of Q1, biasing it on. That, in turn, holds the base of Q2 low, preventing it from conducting. When the melody finishes, U1 goes to its standby state by removing voltage from all pins. The gate of Q1 then goes low, turning it off, and returning base bias to Q2, turning it on. At that point, a pulse is applied to POR terminal pin 8, restarting the melody.

Building the Project. The Music-On-Hold Box was assembled on a small printed-circuit board, measuring 1-7/8 by 2-15/16 inches. A full-size template of the printed-circuit artwork for the board is shown in Fig. 2. If you are not accustomed to producing your own circuit boards from a magazine page, a simple solution is offered in the Parts List: namely, iron-on resist patterns—a process by which the etch-resist pattern is simply ironed onto a copper-clad slug (unetched printed-circuit material). Of course, you'll still have to etch your own board, but at least you won't have to worry about lifting or copying the pattern from the page.

After you've etched and drilled your board, and obtained the parts listed in the Parts List, assemble the circuit using Fig. 3 as a guide. It is recommended that U1 be socketed. Aside from preventing possible damage to U1 during

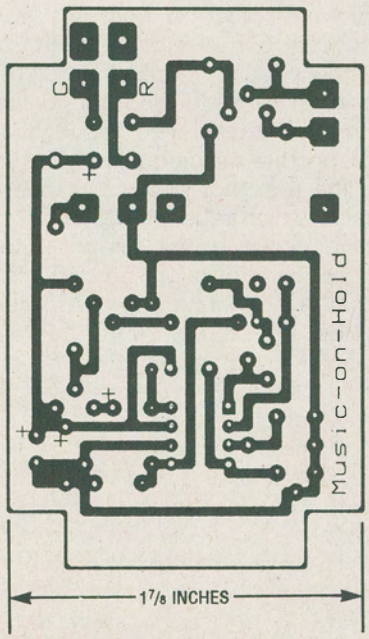


Fig. 2. Here is a full-size template of the printed-circuit artwork for the Music-On-Hold Box's circuit board.

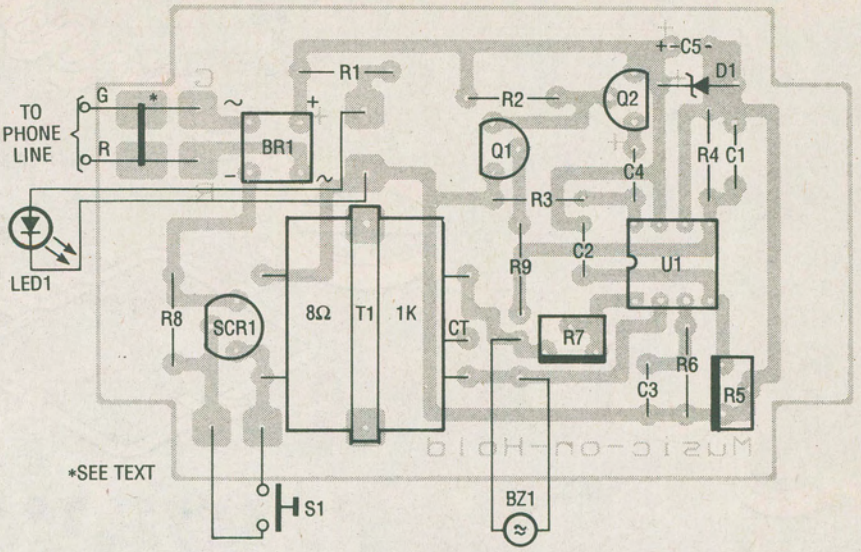


Fig. 3. After you've etched and drilled your board, and obtained the parts listed in the Parts List, assemble the circuit using this diagram as a guide.

soldering, it will permit quick melody-IC changes.

Begin assembly by installing an IC socket where U1 is indicated in Fig. 3. Installing the socket first also aids in finding the proper locations for the other parts. Next, solder all resistors in place, and be sure not to get the potentiometers mixed up. Follow that by placing the capacitors in their proper locations, keeping in mind that two of them (C4 and C5) are polarized and must be properly oriented. Tantalum and electrolytic units have labels on them designating their polarity.

Next install the semiconductor components, and be sure to observe the proper polarity. Transistors Q1 and Q2, and SCR1 come in the TO-92 package style, so they are nearly undistinguishable from each other, save the part number. So consult the part number and pinout information before installing any of those components; it'll save you some aggravation in the long run. If you are not familiar with bridge rectifier markings, the AC inputs on such devices are always marked with a wavy line or indicated by the letters AC, and the plus and minus outputs are marked + and − accordingly. All diodes are also marked; the cathode end is banded.

Now install the transformer. First straighten the transformer leads. Be gentle; When I untangled my first one, I pulled one wire right out of the windings! Cut each lead to about ¾-inch and strip about ¼ inch of insulation from each lead end. Note that although the center tap is not used, a pad is nonetheless provided for that lead. It is recommended that the stranded leads be twisted and lightly tinned before being inserted into their respective circuit-board holes. Tinning helps to prevent bird-caging (fraying) when the leads are inserted. Mount T1 to the board with the center-tapped (3-wire) side toward U1. That insures that the center-tapped primary side is connected to the output of the melody chip. Bend the mounting tabs in toward each other to secure the transformer. Solder all transformer leads in place.

Connect switch S1 to the board through two 4-inch lengths of hook-up wire. Next place a piece of shrink tubing over one lead of the LED, and a second piece over both leads. The first one will keep the LED's leads from shorting. The second will insulate and strengthen both of the leads. Do not heat shrink the tubing at this time. Connect the LED assembly to the board using 3-inch lengths of hookup wire.

Testing. If you haven't done so already, install the melody chip. Set R5 to its mid-position and R7 fully counterclockwise. If you are going to listen to the melody while the person on hold does, connect the optional transducer (BZ1) to the board. If you do not intend to use that option, temporarily connect an 8-ohm speaker in its place. Wire the speaker between either of R7's leads and R5 lead that's furthest from U1. Using a 9-volt transistor-radio battery or DC power supply, apply power to the circuit. The positive side of the supply should go to the pad labeled G and the negative side to the pad labeled R.

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Press switch S1; the LED should light and stay lit until power is removed. The music will begin to play within two seconds of closing S1. Don't worry (if you are using a speaker) if the volume isn't loud enough to hear comfortably; the chip requires an additional transistor to drive a speaker. There will be ample drive power when the circuit is hooked to the phone line via the transformer. Reverse the power leads and verify that the circuit still works.

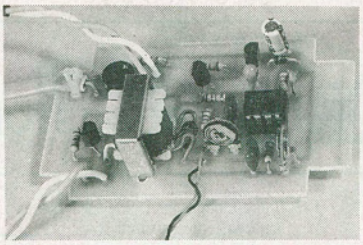
If the circuit does not operate as described, go back and recheck your work. If you get no sound or LED indication, check that placement of BR1 and D1. Be sure that they are properly oriented. If the LED lights, but you get no sound, verify that you've oriented all of the semiconductors, including U1, correctly. Check the setting of R5. If your LED is not lit, but you do have sound, swap the wires going to the LED.

Adjust the melody's tempo, using R5, as needed. Allow the tune to play all the way through. Once the entire melody has played, it will replay after a short delay. If that does not occur, be sure that the voltage at pin 8 of U1 is at a low state and that transistor Q2 is biased on only when the music finishes. Once everything checks out, remove the temporary power supply, and if necessary, the speaker, and shrink the tubing on LED1.

Connect a short length of modular cord (with modular plug) to the board; The green and red wires go to the pads marked G and R, respectively. Connect the phone and the project to the same phone line via a duplex adapter, Y-connector, or similar accessory. Suitable products are available from Radio Shack and elsewhere.

It's also possible to wire the circuit directly to the connector block where the phone line enters the room. The wires are color coded. This method is the most inexpensive way to hook up the circuit, but may require excessively long wire runs.

Verify that the circuit operates as expected when connected to the phone lines. If the circuit doesn't shut off when you pick up your handset after having been on hold, ground the gate of the SCR. If that solves the problem, reduce the value of R8 to 47 ohms or less. Resistor R1 could be also replaced with a 1k to 2k unit to lower the current through



Install the transformer (T1) on the board with its center-tapped (3-wire) side facing U1. Then bend its mounting tabs inward toward each other, and solder all leads in place. Note that even though the center tap is not used, a pad is nonetheless provided for that lead.

SCR1, thereby preventing excessive holding currents. Expect reduced brightness of the LED if that becomes necessary.

As the volume of the circuit is increased, the load placed on the phone lines also increases. If you get unwanted oscillations in the music, increase the value of C5. The final setting of the volume and speed controls (R5 and R7) should be done with someone on the line. If after an honest effort, you can't get the circuit to work properly, send a self-addressed-stamped-envelope to Thumb Electronics (see address in Parts List), detailing your problem. All requests for assistance will be forwarded to the author. List the voltage readings at points G, R, around the SCR, and U1. Once the circuit is working completely to your satisfaction, drill the enclosure for the LED and switch.

Cut a 3/16-inch wide by 1/8-inch deep notch from the upper edge of the enclosure where the lid mounts. That provides passage for the wire going to the phone line. Since both potentiometers face the sides of the enclosure, it is possible to drill holes in the sides of the case to accept a screwdriver for external adjustments. You may wish to fasten the circuit to the side of your phone with velcro. If it is to be put on a table top, use rubber feet on the bottom of the enclosure to prevent scratching.

Other Possibilities. By examining the schematic diagram, it is easy to see how to use the circuit as either a hold circuit or music circuit. You could develop a circuit to have hold with no sound, or add music from a radio or tape player, so that your own taped special hold message or musical preference would be played.

The Music-On-Hold circuit is inexpensive, and easy to build and use. Once in service you will wonder "Why did I go this long without one?" ■