ZERO: An Alerting Device for Repeater Users

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This article outlines a simple emergency calling system that allows your radio to always listen for distress calls. It does so silently, not allowing casual repeater chatter to interrupt your dinner or other activities. No unusual or expensive equipment is required at your station or at the station that may need to summon your help.

Have you ever tried to summon emergency help through a repeater—especially away from your home territory? I have, and it's nervewracking when no one answers your call. You know that the repeater has many users, but for whatever reason, all of them have their radios turned off or have the volume turned down. I know, because I'm one of the guilty. A radio that isn't monitoring the repeater can't be used for emergency communications, perhaps to make a telephone call to the police or other emergency public services on behalf of a mobile station.

At its July meeting, the ARRL Board of Directors endorsed the use of Long Tone Zero (the letter "i" is inserted into the LTZ acronym as a phonetic consideration) as a national alerting signal for VHF/UHF repeaters (ie, a DTMF "0" transmitted for several seconds is a call for help)[1]. This was discussed in last month's FM/RPT, and introduced in the column in November '91 *QST*. This signal will also work on simplex calling frequencies for stations that don't use repeaters or aren't in a repeater's coverage area.

The ARRL LiTZ emergency signal is simple; just send DTMF tone "0" continuously for at least three seconds. A long blast of DTMF tone zero was adopted as the alerting signal because it's logical and easy to remember. Simple, inexpensive decoders can be constructed to detect that signal. Requiring that DTMF tone zero be transmitted for several seconds helps the decoder avoid setting off a false alarm if someone dials an autopatch number or sends a control code that includes a zero.

The idea is to consider the transmission of long-tone zero to be the equivalent of placing an urgent call for assistance or for sending MAYDAY by voice or SOS on CW. It means that the communication is of unusual importance—not a request to ragchew—or may involve someone's personal safety or the protection of property. How do you know if a particular situation warrants a LiTZ call? I use this as my own personal test: If the situation is so significant that I'd be willing to wake up a good friend at 3 AM and ask for help, it warrants a long-tone zero call. A life-threatening emergency is clearly worthy of a LiTZ call. Use of a LiTZ call is appropriate for urgent (PAN[2]) calls, and not just for MAYDAY calls.

What about a local RACES/ARES group that wants a way to call out its membership? For this situation, I suggest a similar system using other DTMF tones. I suggest sending 3-5 seconds of DTMF "1" for a RACES/ARES callout and other signals might be chosen for the NTS and so forth, but let's set those choices aside for now. ZERO can be configured to respond to all of these signals, in addition to DTMF long-tone zero, if the user so chooses.

Here's a DTMF decoder suitable for any ham who wants to be able to lend a hand to a fellow amateur. It's fully compatible with the ARRL-recommended LiTZ system. This decoder, which I call ZERO, can be constructed for less than $35. A healthy junkbox can cut that cost even lower. If you want a LiTZ decoder, but don't want to scrounge parts or don't have the time to build it, there are commercial decoders available that are compatible with LiTZ[3]. Some commercial decoders provide features beyond LiTZ decoding.

Circuit Description

Fig 1 shows ZERO's schematic diagram. ZERO's circuitry is divided into three major parts: the voltage regulator, an inexpensive DTMF-decoder chip and decoder, and the latch-alarm circuits.

Voltage Regulator

An input of 9-16 volts (nominally 12 V) is applied to connector J1. Switch S1 provides on/off control of the decoder. Fuse F1 protects against circuit faults, while diodes D1 and D2 prevent reverse polarity protection for ZERO's circuitry. Capacitor C1 provides RF filtering and bypassing. C2, C3 and C4 handle filtering for the regulator and attached circuitry. Resistor R1 allows a discharge path for C8 during power-off conditions.

Tone Detector and Decoder

R2 and R3 reduce the input voltage to less than 500 mV RMS to ensure that the DTMF decoder (U2) isn't overloaded. Audio input is dc blocked by C6 and passed to U2. Crystal Y1 provides the clock frequency for U2, and R4 provides a dc path to bias the oscillator.

When a valid DTMF signal is detected, U2's DV output goes high, saturating transistor Q3 and lighting DS1, the TONE LED. This is useful for testing to see if the audio level to the tone detector is acceptable.

Desired tone validation is reflected by the voltage on C7. A low voltage on C7 means that the tone is invalid; a high voltage means the tone is valid. C7's purpose is to filter glitches that may be generated by the decoding circuitry formed by D3-D7, U3A and U3B. R5 supplies current to C7 and any of the attached diodes can discharge C7. This time constant is short, about 1 mS, because its only purpose is to remove switching glitches.

When jumper W2 is open, ZERO is configured to respond to *any* long DTMF tone. With W2 open, diodes D3-D6 have no effect. The DV output of U2 goes high whenever a DTMF tone is detected, causing the voltage on C7 to quickly rise as it's charged by R5.

When W2 is installed, ZERO is configured to respond *only* to DTMF long-tone zero. When a DTMF "0" tone is detected, U2 has its D8, D2 and DV outputs high and its D4 and D1 outputs low. Thus, all diodes are cut off and C7 quickly charges to a high voltage through R5. When no DTMF tone, or a tone other than zero, is detected, at least one of the diodes is forward biased and the voltage on C7 is low.

Latch/Alarm Circuit

When the voltage on C7 goes high, the input to U3C is also high, causing the output of U3C to go low. With U3C's output low, D8 is cut off and the voltage at the input of U3D falls at a rate determined by C8 and R8 (RC time constant = 3.3 seconds). When the input to U3D falls below 2 V, the output of U3D goes high. This high signal is fed back to the input of U3C via D10, latching the output of U3C low and U3D high, respectively. These two inverters, which form the decoder latch, remain in this condition until S1 is opened. DS1 illuminates whenever the latch is set.

U3D feeds U3E to invert the latch signal. When the decoder's latch is set, U3E's output goes low, causing two things to happen: First, with U3E's output low, Q1 is cut off and relay K1 is deenergized. This causes the normally closed contacts between the input audio and the speaker to make. That sends the radio's audio output to the speaker, LS1. Also, when U3E's output goes low, the input to U3F goes low (and its output high) for a time constant determined by C9 and R14 (3.3 seconds). During the time U3F's output is high, Q2 is saturated. Q2's collector drives a buzzer device, such as those used in smoke detectors (loud!) and drives K2, a relay

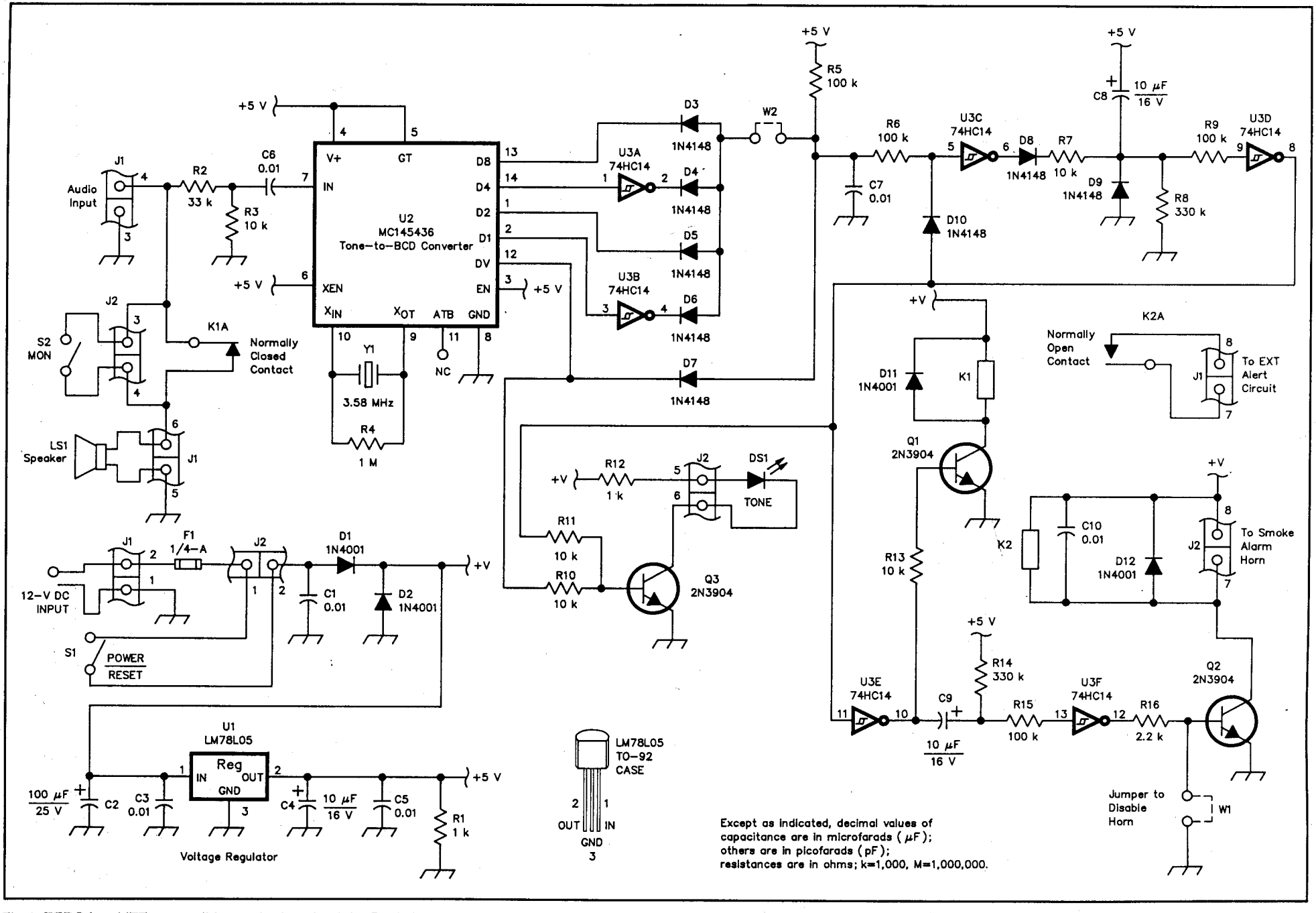


Fig 1–ZERO is a LITZ-compatible monitoring circuit by Paul Newland, AD7I. It's a simple, yet flexible project designed around an MC14536 DTMF decoder and 74HC14 chip. The PC-board template and complete part list is available from ARRL HQ.

whose contacts are available for any external alarm circuits you may want to add.

System Configuration

If you want to be alerted only to LiTZ-type calls, install W2.

If you want to respond to all long-tone calls, regardless of the DTMF tone transmitted, omit W2. Alternatively, you might want to connect a switch at W2. Then, during your nonsleep hours, leave the switch open so you'll be alerted to any type of call. When you go to bed, close the switch so that you'll only be alerted to LiTZ calls.

System Operation

After you've configured W2 to your liking, you're ready to go. When a valid tone is detected for more than three seconds, the speaker is connected to the audio input, the TONE LED lights and the horn sounds for three seconds. Even after the horn stops, the speaker remains connected to the radio and the TONE LED stays lit until the latch is cleared. To clear the decoder's latch, open S1 for a few seconds. C8 will discharge through D9 and R1. The reset components, C8, D9 and R1, ensure that the decoder's latch always clears on power up. When power to the decoder is removed, K1 is deenergized and the radio's output is connected to the speaker.

Whenever the decoder is powered down, the radio operates normally; any audio from the receiver passes through the normally closed contacts of K1 to the speaker. If you want to monitor the radio's audio on the speaker, but still have ZERO look for DTMF signals, close S1 to energize the decoder and close S2 to bypass K1. That way, you can listen "in the background," but a LiTZ signal can trigger your alarm horn or whatever.

Construction

You can use almost any construction method you like. I've built ZERO decoders using point-to-point, wire-wrap and "ugly" construction methods. The only bit of caution I can offer is that Y1 should be physically close to the DTMF detector chip, U2. The crystal's leads and interconnections carry high-frequency signals, so the path should be kept short. Ideally, each crystal lead to U2 should be less than two inches long.

Parts Substitution

Most parts for this project can be obtained from Jameco or Radio Shack[4]. The MC145436 DTMF decoder can be replaced with an equivalent part. However, I'm not aware of a drop-in alternative for U2. If another decoder IC is used, you may need to make circuit adjustments. All resistors can be as small as 1/8 watt; larger physical size and power dissipation are certainly acceptable. I used 1/4-watt, 5% carbon-film resistors because they're cheap. You can probably vary the value of almost any resistor by 30% without significantly affecting the decoder's operation. The same holds true for capacitors. Keep that in mind while looking for parts in your junkbox. The tolerances of cheap electrolytic capacitors can be as great as –20% to +80%, so, if you find that some time constants are long, the electrolytic caps may have greater capacity than specified. In that case, decrease the value of the associated resistor to correct the time constant or change the capacitor. For the 1N4148 diodes, you can substitute any small-signal silicon diodes that don't leak current in the reverse direction. Stay away from 1N60 or 1N34 germanium types, because they're sometimes leaky. Q1, Q2 and Q3 can be almost any NPN transistor type. The 2N2222 and MPS4124 are fine substitutes. The only part you shouldn't carelessly change is U3, the 74HC14. Don't substitute the 74HC14 with any other part type (ie, don't use 74LS14, 74C14, 74HCT14, etc).

Checkout Testing

Connect a jumper or cliplead at W2 and ensure that S2 is open. Next, connect the audio output of your radio to ZERO, but leave S1 open so that ZERO is deenergized. This deenergizes K1, allowing the radio's audio to pass to the speaker. Open the squelch (if you aren't already receiving a signal) and adjust the volume control for a comfortable listening level. Close the squelch. Now close S1 to apply power to the decoder. Use a hand-held transceiver connected to a dummy load antenna (or other suitable signal source) to send a brief DTMF signal to the monitor radio. You shouldn't hear anything from the speaker. While the transmitter is active, press each DTMF button and see that the TONE LED on ZERO lights in step with each button press. Transmit DTMF tone "3" (or button "A," if available) while varying the volume control on the radio to see how loud and how soft the audio can be for ZERO to still detect the signal. Check that the volume control setting that provides a comfortable listening level falls within the range of volume settings where ZERO can detect tone "3" (or "A"), which is the most difficult tone to detect. Next, transmit DTMF tone "3" for 10 seconds. The TONE LED is on solid during that time, but the horn doesn't sound.

Next, transmit DTMF tone "0" for 10 seconds. The TONE LED is on solid during that time, and after about three seconds, the horn sounds for a few seconds. (If a jumper is installed at W1, the horn won't sound.) You should also hear the tone coming from the speaker. Stop transmitting. You should now see that the TONE LED is constantly lit and that any audio from the radio is heard from the speaker. ZERO should remain in this state until power is removed. To reset the decoder, open S1 for a few moments and then close it again to arm the decoder; the TONE LED should now be off.

Next, remove W2. Transmit DTMF tone "3" for 10 seconds. The decoder should respond as it did above with tone "0." The speaker, light and horn should be active as before.

Again, leave W2 open if you want to respond to *any* long DTMF tone digit. Install W2 if you want to respond only to long-tone zero. That completes the testing.

Operation

Operation is straightforward. To use your radio as you normally would for communications, open S1. The audio passes through the normally closed contacts of K1 and is heard on the speaker. To mute the speaker, but remain ready for DTMF long-tone calls, close S1. Now your decoder is armed and listening. The speaker remains quiet until the desired long tone is detected, or S1 is opened again for normal operation. To enable ZERO for tone detection, but still be able to monitor the channel, close S1 and S2.

Conclusion

Instead of turning off your radio so that stations in distress can't reach you, spend some enjoyable hours building this decoder and you can always be available for emergencies.

If you have suggestions for improving the decoder, please let me know. Please include an SASE for any replies.

Notes

[1]DTMF stands for dual-tone multifrequency signaling. This is the same thing as "touchtone," a system developed by AT&T's Bell Laboratories as a replacement for rotary telephone dials.

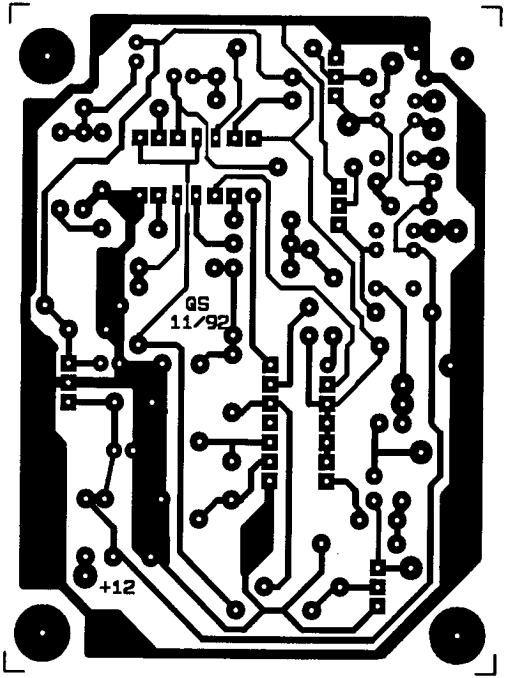
[2]The ITU Radio Regulations defines PAN (pronounced "PAHN") as the procedural signal just below MAYDAY on the severity scale. Radio operators use this for situations that are dicey, but don't meet MAYDAY criteria.

[3]MoTron Electronics (310 Garfield St, Suite 4, Eugene, OR 97402, tel 800-338-9058 or 503-687-2118, fax 503-687-2492) offers DTMF decoders as kits, and wired and tested units. MoTron's basic unit, which is LiTZ-compatible, is the AK-1K (a kit), for $39.95, or the wired and tested AK-1W for $49.95, plus $5 s/h.

[4]Parts may be located from the following sources: The perf board, relays, fuse, switches, connectors and horn can be found at Radio Shack. Other components are available from Jameco, 1355 Shoreway Rd, Belmont, CA 94002; tel 800-831-4242, fax 800-237-6948.

A part list and PC board template is available free from ARRL HQ. Address your request for the NEWLAND ZERO CIRCUIT TEMPLATE to the Technical Department Secretary, ARRL, 225 Main St, Newington, CT 06111. Please enclose a business-sized SASE.

A PC board for this project is available for $6.50, and a PC board with the MC145436 and 74HC14 chips is $12 from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9545. Add $1.50 s/h. Check or MO; credit cards are not accepted. FAR includes the complete parts list and component overlay with either order.


QS
11/92
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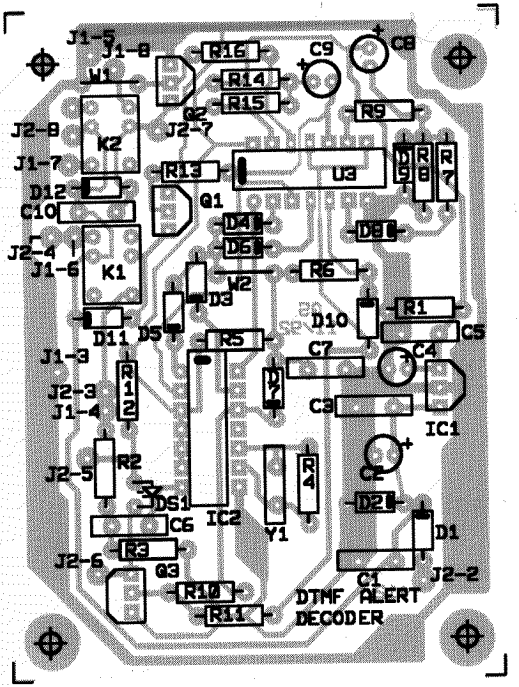
J1-9
J1-8
R16
C9
C8
W1
R14
R15
Q2
R9
J2-8
J2-7
K2
R8
R7
J1-7
R13
U3
D12
Q1
C10
D4
D8
J2-4
J1-6
K1
D5
R6
W2
D3
R1
D11
D5
R5
D10
C5
C7
C4
J1-3
R12
J2-3
J1-4
C3
IC1
R2
J2-5
C2
R4
DS1
D2
C6
IC2
Y1
D1
R3
J2-6
Q3
C1
J2-2
R10
DTMF ALERT
R11
DECODER

1 INCH

Parts List for ZERO 920904

Ref Des	Description	Notes	Vendor	Est Cost
C1	0.01uf / 25v		Jameco	$0.10
C2	25 uF / 25v		Jameco	$0.20
C3	0.01uf / 25v		Jameco	$0.10
C4	10uF / 16v		Jameco	$0.20
C5	0.01uf / 25v		Jameco	$0.10
C6	0.01uf / 25v		Jameco	$0.10
C7	0.01uf / 25v		Jameco	$0.10
C8	10uF / 16v		Jameco	$0.20
C9	10uF / 16v		Jameco	$0.20
C10	0.01uf / 25v		Jameco	$0.10
D1	1N4001		Jameco	$0.20
D2	1N4001		Jameco	$0.20
D3	1N4148		Jameco	$0.10
D4	1N4148		Jameco	$0.10
D5	1N4148		Jameco	$0.10
D6	1N4148		Jameco	$0.10
D7	1N4148		Jameco	$0.10
D8	1N4148		Jameco	$0.10
D9	1N4148		Jameco	$0.10
D10	1N4148		Jameco	$0.10
D11	1N4001		Jameco	$0.10
D12	1N4001		Jameco	$0.10
DS1	RED LED		Jameco	$0.25
F1	1/4 A Fuse	Optional	Jameco	$0.50
K1	Relay	SPDT 12V RS275-241	RadioShack	$2.00
K2	Relay	SPDT 12V RS275-241	RadioShack	$2.00
Q1	2N3904		Jameco	$0.15
Q2	2N3904		Jameco	$0.15
Q3	2N3904		Jameco	$0.15
R1	1K 1/4W		Jameco	$0.10
R2	33K 1/4 W		Jameco	$0.10
R3	10K 1/4 W		Jameco	$0.10
R4	1M 1/4 W		Jameco	$0.10
[illegible]	100K 1/4W		Jameco	$0.10
	100K 1/4W		Jameco	$0.10
	10K 1/4 W		Jameco	$0.10
	330K 1/4W		Jameco	$0.10
	100K 1/4W		Jameco	$0.10
	10K 1/4 W		Jameco	$0.10
	10K 1/4W		Jameco	$0.10
[illegible]12	1K 1/4W		Jameco	$0.10
R13	10K 1/4W		Jameco	$0.10
R14	330K 1/4W		Jameco	$0.10
R15	100K 1/4W		Jameco	$0.10
R16	2.2K 1/4W		Jameco	$0.10
S1	SPST Switch	SPST, 275-406	Radio Shack	$0.50
S2	SPST Switch	SPST, 275-406	Radio Shack	$0.50
S3	SPST Switch	SPST, 275-406	Radio Shack	$0.50

Parts List for ZERO 920904

Ref Des	Description	Notes	Vendor	Est Cost
U1	78L05		Jameco	$0.35
U2	MC145436	DTMF Decoder		$5.00
U3	74HC14	Do Not Substitute	Jameco	$0.50
Y1	3.58 MHZ XTAL	Parallel Mode	Jameco	$1.50
Z1	Perf Board	276-147	Radio Shack	$4.00
Z2	Horn	273-051	Radio Shack	$2.50
		Total Estimated Cost		$24.95