MAGENTA ELECTRONICS BAT DETECTOR MKII Designed by Mark Stuart

Introduction

This version of the Magenta Bat detectors was designed to be easily assembled by electronics hobbyists, low cost, and reliable. It is a 'heterodyne' circuit which mixes a variable frequency oscillator with the received ultrasound to produce an audible output. It covers the range from 20kHz up to 140kHz and is suitable for group use, as it has a powerful audio output stage that can drive up to 0.5 Watts into a 16 ohm load. A standard 3.5mm jack socket can be added for personal stereo headphones or connecting to a tape recorder. The circuit uses a high performance balanced mixer which minimises noise and interference and operates at low current levels.

Circuit Description

The circuit diagram is shown in Fig. 1. TR1 and TR2 form a two stage ultrasonic amplifier. The capacitor values C1, 2, and 3 have been chosen so that the amplifier gain falls off steeply below 20kHz to cut off any audio frequency sounds that may be picked up.

From the amplifier the signal passes to the mixer circuit IC1 where it is combined with the signal from oscillator IC2. The frequency of oscillation is set by the charging and discharging of C10 via R8 and RV1. R8 sets the high frequency limit to 120kHz when RV1 is set to minimum, and when RV1 is set to maximum the low frequency limit of 20kHz is produced. The output from IC2 is initially a square wave, but this is filtered to remove harmonics and lowered in amplitude to a suitable level by R7, C7, and C8.

The output from the mixer consists of two signals - one is the sum of the two input frequencies, and the other is the difference. The sum is always above the audible range and is not wanted, whilst the difference is the wanted 'heterodyne' signal which contains all the characteristics of the received ultrasound but shifted down in frequency. If a simple mixer had been used, the output signal would have also contained the oscillator signal and the original ultrasound signal. A 'double balanced mixer' of the type used in this circuit cancels out these two unwanted signals.

The output from the mixer is passed via R10, C9, and C11 to audio amplifier IC3. The gain of IC3 is controlled by RV2 which varies the DC voltage level applied to pin 4. This type of control is becoming more popular as it allows a simple linear variable resistor to be used, and allows the audio signal to be connected directly to the IC - avoiding possible interference pick up.

Amplifier IC3 is a 'full bridge' type containing two output amplifiers which operate in opposite phase driving one end each of the speaker. This arrangement is particularly effective where low voltage supplies are used as it allows twice the output voltage swing to be obtained. It also means that there is no need for an output coupling capacitor. Another useful feature of IC1 is that it has internal 'automatic shut down' protection from short circuits and overheating.

Assembly

The circuit is built on a single printed circuit board (pcb) which is mounted by means of four screws and spacers on to fixing posts moulded into the case. A separate small board is used to mount the ultrasound microphone.

Loudspeaker

The loudspeaker is a special low profile type with a waterproof mylar cone. It is necessary to remove the centre pcb mounting pillar from the inside of the case front so that the speaker can fit correctly. The pillar can be removed easily with sharp wire cutters, or can be drilled out with an oversize drill. Make sure it is removed completely so that there is nothing left that might touch the speaker cone and cause ’buzzing’ sounds. Fit the speaker using a solvent based ‘household’ adhesive. Make sure the adhesive goes all the way round the black mounting face but does not touch the speaker cone and fit the speaker with the two solder tags facing towards the battery compartment. Attach one sticky pad to the top of the speaker magnet as a spacer to make sure the bottom of the pcb does not contact the speaker.

Microphone mounting

The microphone is mounted (either way round) on a separate small board. Make the connections to the board before fitting it into the case. The two copper connecting pads should be closer to the LED hole in the case. The print on the microphone side of the board shows which way round to connect the screened lead to the rectangular undrilled pads on the rear of the board. Take care to connect the screen to the correct point on both pcbs otherwise the lead will behave more like an antenna and strong radio stations will be picked up! Fix the microphone board to the front end of the case using two layers of resilient ‘sticky pads’.Take care to centre the microphone in the hole so that it does not touch the case.

If a headphone socket is to be used, a single 6mm hole should be drilled in the side of the case nearer RV2. It is a good idea to do this last - to make sure the socket doesn't get in the way of the main board or other components.

PCB Assembly

Use the parts list, the component layout diagram Fig. 2, and the printed layout on the pcb. Fit all of the resistors, and use one offcut resistor lead in the position marked 'LINK'.

Next fit the IC sockets. *(note that the IC sockets have one end different from the other to indicate which way the IC should be inserted. Note also that IC1 fits the opposite way round from IC2 and IC3 - see the notches shown in Fig. 2.)*
Make sure all 8 of the IC socket pins go through the board as they can be inclined to fold invisibly under the socket moulding.
Fit the transistors so that their outline shape matches Fig. 2 and finally the capacitors. Note that only C4 and C12 have their polarity marked - usually by a band of ' - ' signs adjacent to their negative leads. These two must be mounted as shown with their positive leads next to the ' + ' signs on the layout drawing. The other capacitors are non polar, so can be fitted either way round.

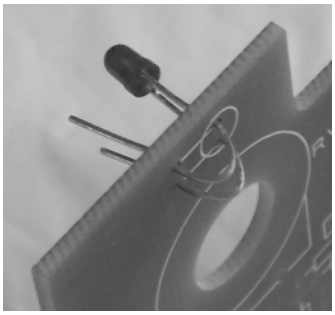
The two controls, RV1, and 2 are mounted from the component side so that their spindles pass through the board to the copper track side. RV2 is the volume control and also has an on/off switch. Fit the mounting washers and nuts and make sure that the connecting tags fit correctly. One twisted pair of wires should be fitted for the speaker, and one for the headphone socket, if it is to be fitted. The headphone socket is connected with one wire to the 'common' or sleeve terminal which is nearer to the threaded fixing, and the other wire to both the ring and tip terminals at the rear of the socket. Inspection of the socket will show which connection is which.

Fig 2 shows the headphones and loudspeaker connected in parallel so that they work together. This works well as the headphones are normally used at low volume levels that are nearly inaudible in the speaker. If required, a miniature slide switch can be added to allow the speaker to be muted when headphones are used.

The battery clip is connected with the black (negative) wire to the point marked ' 9V BAT NEG' on the board, and the red (positive) wire to one of the tags on the on/off switch indicated as '**B**' '9V BAT POS'. The other tag '**A**' on the on/off switch must be connected with a short length of insulated wire to the adjacent point indicated on the board.

Indicator light

A low current l.e.d. indicates when the circuit is switched on, provides a useful indication that the battery is not flat, and acts as a reminder to switch off after use. The l.e.d. is push fit into the 3mm diameter hole in the case, and should be mounted on the board to allow some flexibility in the leads as shown in the picture. The longer lead is the positive and is nearer the top edge of the board. Leave the leads unsoldered until assembly is completed and the led can be positioned accurately. Solder ONLY to the two pads on the left side of the picture. This will allow the loops in the led wires to be manipulated to adjust the led position.



Testing

When assembly is complete and when the board has been inspected for dry joints, solder bridges, and incorrect components, the circuit can be tested. Start with all ICs removed so that any gross faults such as solder bridges show up before they can damage anything. It is useful to be able to measure the circuit current drain whilst testing. and to have a simple current limiting device in circuit to limit fault current. A 10 ohm resistor in series with the battery is a very effective way of saving components from distress. Complete the testing with the board loosely in position. Don't fit the mounting screws and pillars until everything is working correctly.

Without the ICs, switch on and check that the current drain is around 5mA. Check that the l.e.d. Is lighting , and that the on/off switch works correctly.
Switch off, fit IC3 and there should be slight background noise in the speaker as the current rises to 10 mA or more and the volume control is advanced. Adding IC1 will increase the current and background noise only slightly as there is no oscillator signal. Finally turn down the volume control and add IC2. The noise level should now be higher, and simple sounds should be picked up - jangling keys, rubbing dry hands together, and many other 'ordinary' sounds have substantial ultrasonic components and will be heard easily. Any resistance fitted in series with the battery will have to be removed from this step onwards, as the extra voltage drop caused will limit the available output and probably give rise to low frequency instability. At this stage the detector is ready for final assembly.

Cutting the Spindles:

Before mounting the board, cut the spindles of RV1 and RV2 to a suitable length using a fine small hacksaw. MAKE SURE to allow for the extra pcb mounting spacers and don't cut the spindles too short. Clean away all the plastic 'bits' before fitting the label.

Labelling:

The self adhesive front panel label is easier to fit if the spindles of RV1 and RV2 are not showing through the holes. Wipe the front of the case to make sure there are no small particles that will be trapped under the label. Peel the label backing, remove the 'blanks' from the four label cut-out holes, align and fix the label to the case using the case front recess as a guide. The adhesive allows repositioning, but try to avoid it if possible.

Mounting The pcb

The pcb mounts on four pillars moulded into the case, but must be raised by spacers in order to clear the loudspeaker. Fit the four mounting screws through the holes in the board - note that the screws will have to be 'screwed' through the board because the holes are tight, but this will be an advantage as the screws are retained while the spacers are fitted. This operation is best done 'upside down' otherwise the spacers fall off the screws! Position the screws in the pillars and then turn them so that they spin in the pcb and bite the pillars. Note that the screws are a little oversize, but that they make good rigid mounting for the board. Take care not to overtighten them because the pillars are relatively soft and can be stripped or split.

Bat Detecting!

Unless you have a tame Bat, (which is probably illegal) there is no other way of testing except to wander out at dusk, stand, and wait. Start listening at 40kHz and medium volume. Remember that ultrasound is very directional so move the detector to scan the area. Jangling keys will produce plenty of ultrasound for functional tests.

Battery.

The battery life depends upon the volume level. Most of the power drain will be that used by IC3 driving the speaker. The circuit will give reasonable life from a standard PP3, but an alkaline type is recommended for regular use. Modern 8.4 Volt NiMH rechargeables are also suitable and give satisfactory life between charges.

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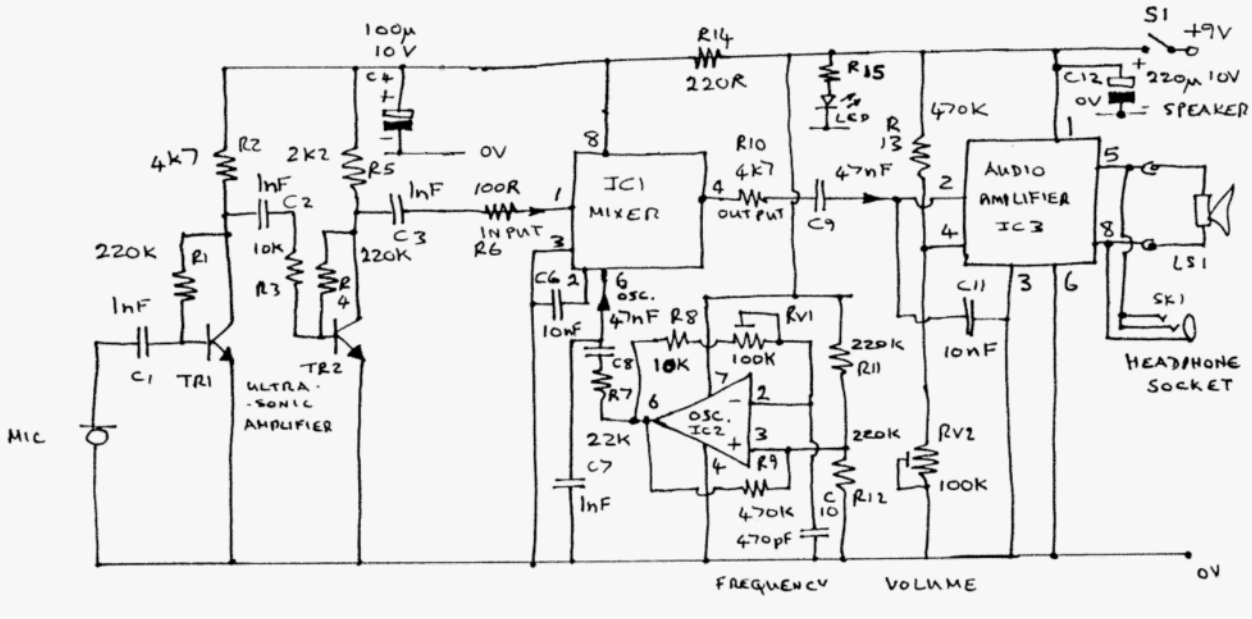
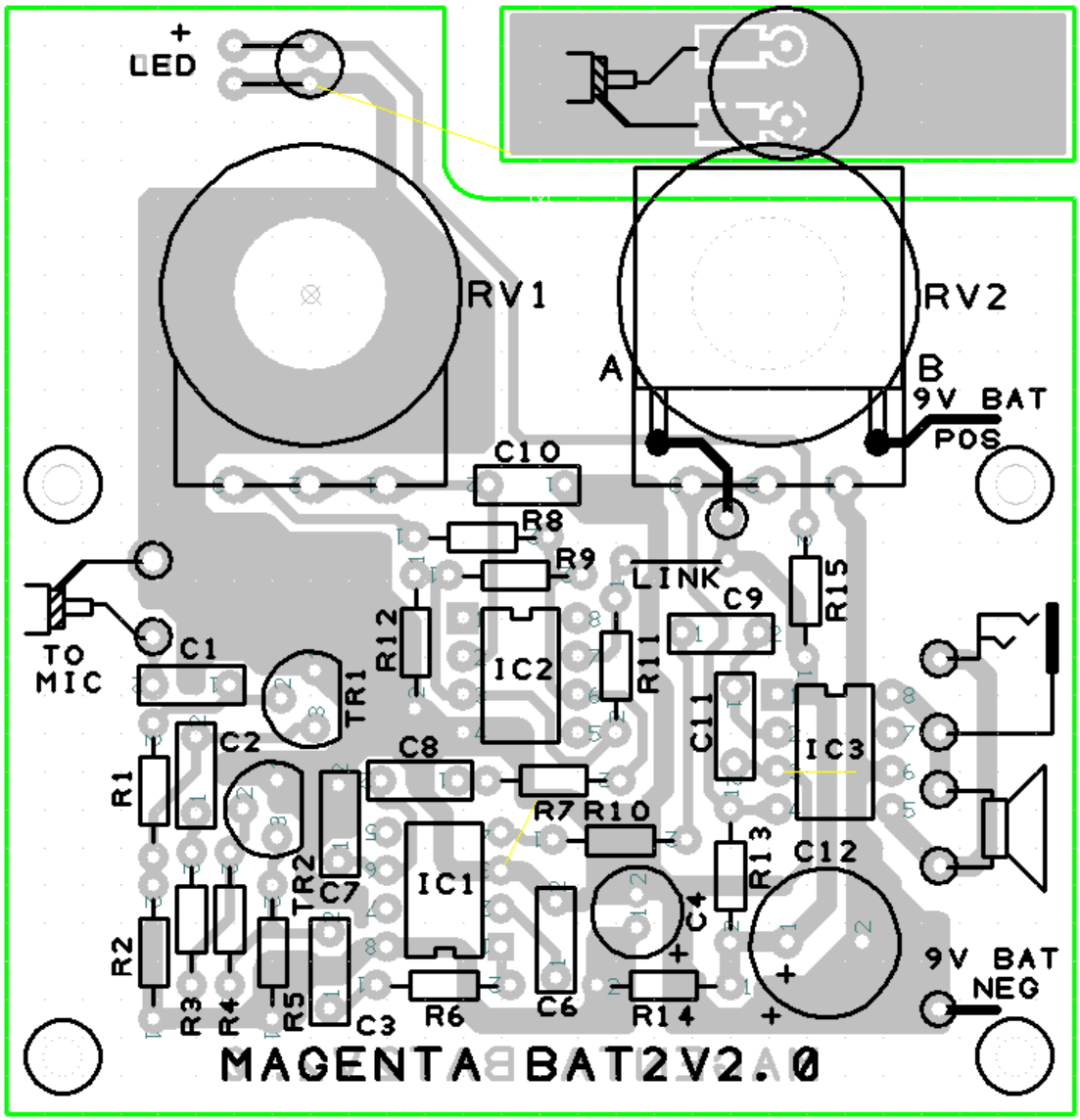
Fig. 1 MkII Bat Detector - circuit diagram





Top Silk Screen

R1,4,11,12	220k	0.25W 5% Carbon Film Resistors
R2, 10, 15	4k7	
R3, 8	10k	
R5	2k2	
R6	100R	
R7	22k	
R9,13	470k	
R14	220R	
RV1	100k LIN	Min. Pot
RV2	100k LIN Sw.	Min. Pot. + SPST Switch
C1, 2, 3, 7	1nF 50V 10%	Film type 5mm lead pitch
C4	100uF 10V	Rad. Elect. 6mm dia
C5*	- Not Used	-
C6, 11	10nF 50V 20%	Ceramic 5mm lead pitch
C8,9	47nF 50V 20%	Ceramic 5mm lead pitch
C10	470pF 50V 10%	Ceramic2.5/5mm lead pitch
C12	220uF 16V	Rad Elect. 10mm body dia.

TR1, 2	BC184 NPN
IC1	SAA602 Double Bal. Mixer
IC2	TL071 Op Amp
IC3	TDA7052A Audio Amp
LED	3mm low current l.e.d.
MIC	M10-227 Ultrasonic Mic.
LS	16 Ohm Speaker
SK1	3.5 mm Socket

Battery Clip, Case, Label, 2 Knobs,
Main pcb, Mic pcb, Screened lead 8cm,
7/0.2 con. wire 6 colours 15cm each,
5 Small square sticky pads,
4 No 4 x 13mm Screw,
4 x 5mm plastic spacers

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