Building the

Geotech Baracuda
(Rev-A)

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August 2020

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Introduction

The Geotech Baracuda is based on the original Baracuda from Anchor Electronics. The design was first published by Alexismex in 2011 and (although people have reported some success) there have been a number of underlying problems with many of the builds, particularly when using a supply voltage that is too high. There are also several versions of the Baracuda schematic floating around, with each of them containing subtle differences, and many of these have discrepancies between the schematic and the layout. Following a number of Geotech members experiencing issues with this design, it was decided to take a closer look and try to isolate the source (or sources) of these problems. After close examination, the following issues were discovered:

1. The original voltage converter (that generates the -5V supply) was based on an ICL7660. The main problem here is that the ICL7660 has a maximum allowed input voltage of 10.0V. In many cases this has been replaced with the ICL7660A, which has a higher maximum input voltage of 12.0V. Even so, this is not sufficient to allow the detector to operate from a 12V battery, as the nominal voltage can easily be as high as 13.0V or above. Hence it was often the case that the converter was being damaged by over-voltage. In the Geotech Baracuda, the ICL7660 has been replaced with an LT1054. This voltage converter is pin-compatible with the ICL7660, but has a maximum input voltage of 15.0V. As with the original design, the LT1054 is synchronized with the TX oscillator.

2. The 40106 (hex Schmitt trigger inverters) is used to generate both the TX and sample pulses. In the sample pulse generator, there are four pull-up resistors in the original design which are connected to +5V. This is a design fault, as the power pins are connected to 0V (VDD pin) and -5V (VSS pin), and therefore the pull-up resistors should be connected to 0V. It was noted, prior to this modification, that the detection distance for a large coin was about 6", which is a typical figure quoted by other constructors. However, following the above changes, the detection depth increased dramatically to 12" with a 300uH 9" diameter mono coil, plus there was an increase in stability of the audio threshold.

3. The offset null circuit was non-standard and did not match the recommended configuration shown in the datasheet. This has been corrected.

4. If you examine the schematic in the area of the power supply (top right in the original design), you will see that there is a 220uF electrolytic capacitor connected between VSS (-5V) and VDD (+5V). At power-on, the 78L05 becomes active first (since it's connected to the battery input) whereas the 79L05 is driven from the output of an ICL7660. This charge pump takes a finite time to get started, with the result that the -5V supply lags behind the +5V supply when the battery is connected. Unfortunately there is a 220uF electrolytic capacitor connected between the +5V and -5V supply lines. This is wrong, and there should be two separate capacitors connected from each of the power supplies to 0V (not to each other). When the battery is connected, the 220uF capacitor looks like a short-circuit, which means that the +5V supply gets connected momentarily to the -5V supply. The result is that the CD40106 has its power line connected in reverse when the detector is switched on, and consequently the device lets out the magic smoke and stops working.
There was also no smoothing capacitor at the output of the 79L05.
These issues have been remedied in the Geotech Baracuda (REV-A) design, as the capacitors are now correctly connected between the power supply outputs and 0V. C1 has also been reduced in value from 4700uF to 1000uF.

5. In addition it was necessary to adjust some of the component values to compensate for the changes made to the pull-up resistors in the sample pulse circuit.

6. A discrepancy was found in the audio stage between Apberg's schematic and the PCB layout. The schematic showed a 100R resistor in series with the emitter of the audio output transistor, but the layout had the resistor placed in series with the collector. Putting the resistor in the emitter circuit is incorrect, and results in a low volume audio output.

7. In various schematics, C20 ranged from 100pF to 100nF. In some cases the capacitor shown on the schematic was different to the one fitted on the PCB, and/or listed in the parts list. In the revised design, C20 has be specified as 100nF.

8. The only other significant change is the PCB layout, which is completely different, with the exception that the board dimensions have been kept the same. The layout is now double-sided with a ground plane on the bottom layer.

The intention here was to keep the design as close to the original as possible, but to remove the existing design flaws without making major changes. As a consequence, there are still a few fundamental issues that could benefit from a redesign, but that is beyond the scope of this exercise. The final result is that we now have a fully functioning and robust Baracuda circuit that actually performs better than the original.

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Please note that it is highly recommended you have access to an oscilloscope during the setup procedure. Although it is not impossible to successfully build a working unit without one, you will need to be very careful and methodical during the construction. However, it *is* mandatory that you possess a multimeter.

If you go through the following steps carefully, and in order, you will have a greater chance of ending up with a detector that actually works. Please do not proceed to the next step until you have solved any problems encountered in the current step. If you get stuck at any stage during the build, then seek help in the Geotech forums before moving on. Do not simply populate the whole board; discover it doesn't work (which will be the most likely result) and then post in the forums: "I've built the Geotech Baracuda, and it's not working. What's wrong?" …. as you will receive little sympathy from other Geotech members.

To reiterate:

Please follow the instructions step-by-step.

Important Points

Check the value of each component before you start soldering. Fitting an incorrect value in the wrong place is one of the most common mistakes.

The negative (-ve terminal) of the battery pack is treated as ground (0V) in this design. All voltages and currents are referenced to this point.

The original release of this design had Q1 specified as an IRF9530 (same as the original Baracuda), but the kit supplied by Silverdog (www.diydetector.co.uk) replaces this with an IRF9640. The latter has a breakdown voltage of -200V, as opposed to -100V for the original. This change increases sensitivity as the mosfet spends less time in avalanche mode and the preamp comes out of saturation earlier.

Step-by-step Instructions

STEP 1

Starting with the +5V supply (see Fig. 1):

Fit PL1, C4 (220u), D3(1N4001) and U3 (78L05).

This is a simple linear regulator that provides the +5V power supply. Check the supply is correct by connecting a 12V battery pack to PL1 (the positive terminal is the middle pin, and both outer pins go to the negative terminal). This use of a 3-pin connector is to prevent the circuit from accidentally being connected to the battery in reverse. Check the voltage at a suitable point such as U7 pin 8, and confirm that it measures +5V (see Fig. 2).

STEP 2

Next we will build the -5V supply (see Fig. 1):

Fit R23 (39k), R25 (2M2), C21 (470n), C17 (10u), C22 (10u), C23 (220u), D8 (1N4148), U6 (79L05) and U5 (LT1054).

The LT1054 is configured as a voltage inverter, changing the positive battery voltage to negative, which is then regulated by U6 (79L05) to -5V. Check the voltage at a suitable point such as U7 pin 4, and confirm that it measures -5V (see Fig. 3).

The LT1054 is synchronized to the TX circuit via R23, R25, C21 and D8.

STEP 3

The transmit (TX) oscillator (see Fig. 4):

Fit R10 (150k), R11 (6k8), R12 (100k), C5 (6n8), C8(100n), D4, D5 (1N4148), and U4 (40106).

If no scope is available, then attach a high impedance speaker between U4 (pin4) and 0V, and you should hear a low-volume high-pitched audio tone.

You can also see that the TX oscillator is synchronized to U5 (LT1054 voltage converter) by monitoring U4 (pin4) with an oscilloscope (channel 1), and U5 (pin 7) (channel 2).

STEP 4

Transmit (TX) circuit (see Fig. 6):

Fit R1 (330R - 2W), R2 (150R), R3 (1k), R13 (33k), C1 (1000u), C6 (100n), Q1 (IRF9640), U1 (2N2222) and CONN1.

The coil inductance should be between 300uH and 500uH. You can utilise the Coil Calculator (at the top of the Coil forum) to determine the correct number of turns for the diameter you intend to use. The damping resistor (R1) may need to be adjusted to suit your particular coil. This resistor can be positioned on the PCB, or alternatively it can be fitted on the back of the coil connector, or even inside the coil shell itself. Initially you can connect the damping resistor across CONN1 with the wires from the coil. When you are satisfied that you have the correct value, fit the damping resistor in one of the positions previously mentioned.

If you have an oscilloscope, then monitor the signal across the damping resistor using a x10 probe, where you should see a flyback signal of about -200V, which is the breakdown voltage of Q1. If no oscilloscope is available, then put on a set of headphones and place your head close to the TX coil. A high-pitched audio tone will be induced into the speaker coil of the headphones if the TX circuit is working correctly.

STEP 5

RX preamp (see Fig. 7)

Fit R4 (1k), R5 (1M), R6 (100k trimmer), R7 (1k), R8 (22k), R9, R22 (27R), R16 (150R), R18 (10k), C2, C18 (47u), C3, C15, C19 (100n), D1, D2, D6, D7 (1N4148) and U2 (NE5534)

Measure the DC voltage on U2 pin 6, and adjust R6 to give 0V.

STEP 6

Sample Pulse Generator (see Fig. 8):

Fit R14 (20k trimmer), R15 (15k), R17 (150k), R21 (12k), C7, C12, C13, C14 (4n7), PL2 (10k Sample Delay Pot).

Monitor the TX oscillator using an oscilloscope at U4 (pin 4) using channel 1, and main sample delay U4 (pin6) using channel 2. Trigger off channel 1. Short pin1 of PL2 to pin2 and adjust R14 for a minimum sample delay of 20us. The final minimum sample delay will depend on the coil you've constructed, but 20us will be ok for initial setting up. If no oscilloscope is available, then

build the sampling integrator in Step 7 before adjusting R14.

Main sample delay = 20us (U4 pin 6)
Main sample pulse width= 48us (U4 pin 10)
Secondary sample delay (EFE) U4 pin 8 = 500us + main sample delay
Secondary sample pulse = 48us (U4 pin 12)

The timings above are *nominal* values and will vary somewhat due to component tolerance.

STEP 7

Sampling integrator (see Fig. 10):

Fit R19, R20 (270k), R26, R27 (1k), C10, C11 (470n), C16, C24 (100n), Q2, Q3 (2N5485) and U7 (LF412A) .
Monitor U7 (pin 1) with an oscilloscope or a voltmeter, and confirm the DC voltage level increases when a target is placed near the coil.
If you did not make the adjustment to R14 (Step 6) using an oscilloscope, then do it now while monitoring U7 (pin 1) with a voltmeter. Set the DC voltage level to around 2.3V. Make sure you attach your coil and short pin1 of PL2 to pin2 (before adjusting R14) otherwise the voltage will not change. Alternatively you can also make the adjustment by removing the short between pin1 and pin2 of PL2, and adjusting R14 to read 8k3 by connecting a multimeter between PL2 pin1 and U4 pin5.

STEP 8

Second integrator (see Fig. 11):

Fit R28 (39k), R29, R30 (100k), R31 (33k), R32 (27k), R33 (1k), C9 (470n), C25 (100n) and PL3 [Audio (threshold) 47k pot].
Monitor U7 (pin 7) with an oscilloscope, and adjust the Audio (threshold) pot. Set the DC level to around 0V. While still monitoring U7 (pin 7), look for a change in the DC voltage level as a target is moved across the coil .

STEP 9

Audio (VCO) stage (see Fig. 12):

Fit R24 (2M2), R34 (22k), R35 (100k), R36 (100R), R37 (33R), C20 (100n), D9, D10 (1N4148), PL4, Q4 (2N5484) and U8 (MPSA13) .
Connect a speaker or headphones to PL4. Since there is no volume control, it would be advisable to use headphones with built-in volume controls.

Other Points:

1. The detector is designed to run from a 12V battery pack. The absolute maximum input voltage is 15V. Anything above this could destroy the voltage converter (U5).

2. The Baracuda effectively eliminates the Earth Field response, even though the main sample pulse width and the EF pulse width are not consistently the same for all main sample delay settings. This is a basic issue with the original design, but is adequate for normal use.

3. The audio response of the Baracuda varies in volume depending on the target strength. The audio tone remains constant, unlike many other PI designs that either vary the tone, or both the volume and tone simultaneously.

4. The Audio [threshold] pot should be adjusted to give a low background tone, and any detected target will increase the volume.

5. All of the components, that connect to the PCB via connectors, can be inserted either way round without any problems. However, the Audio [threshold] pot and the Main Sample Delay pot will react differently depending on their orientation. Make sure you connect the pots the correct way round if you want the audio and the sample delay to increase as you turn them clockwise.

6. A 330R damping resistor is shown in the schematic, but the actual value required will depend on the coil being used. Note that the Baracuda design tends to require lower damping resistor values that most other designs. This is partly because of the absence of a series resistor and diode, but is mainly caused by the mosfet being turned off passively via a 1k resistor.

7. The audio output is louder with higher resistance speakers.

Component Parts List

Resistors (1% 250mW, unless stated otherwise)

Qty	Description	Ref Des
1	40106 hex Schmitt inverter	U4
1	1000uF electrolytic	C1
4	100k resistor	R12,R29,R30,R35
1	100k multi-turn preset	R6
9	100nF capacitor	C3,C6,C8,C15,C16,C19,C20,C24,C25
1	100R resistor	R36
1	10k resistor	R18
2	10uF electrolytic	C17, C22
1	12k resistor	R21
2	150k resistor	R10,R17
2	150R resistor	R2,R16
1	15k resistor	R15
6	1k resistor	R3,R4,R7,R26,R27,R33
1	1M resistor	R5
1	1N4001 diode	D3
9	1N4148 diode	D1,D2,D4-D10
1	2-pin terminal block	CONN1
2	220uF electrolytic	C4,C23
2	22k resistor	R8,R34
1	20k multi-turn preset	R14
2	270k resistor	R19,R20
1	27k resistor	R32
2	27R resistor	R9,R22
2	2M2 resistor	R24,R25
1	2N2222 npn transistor	U1
1	2N5484 n-channel FET	Q4
2	2N5485 n-channel FET	Q2,Q3
1	330R 2W resistor	R1
2	33k resistor	R13,R31
1	33R resistor	R37
2	39k resistor	R23,R28
4	3-pin connector	PL1-PL4
4	470nF capacitor	C9-C11,C21
2	47uF electrolytic	C2,C18
4	4n7 capacitor	C7,C12-C14
1	6k8 resistor	R11
1	6n8 capacitor	C5
1	78L05 voltage regulator	U3
1	79L05 voltage regulator	U6
1	IRF9940 p-channel MOSFET	Q1
1	LF412A dual BIFET opamp	U7

```
1     MPSA13 transistor          U8
1     NE5534 opamp               U2
1     LT1054                     U5
1     10k pot (delay)            PL2
1     47k pot Audio (threshold)  PL3
```

Miscellaneous

```
Battery pack              8x AA batteries (12V nominal)
Search coil               300uH to 500uH (TX)
Speaker                   8ohm to 64ohm
On-Off switch             Separate or combined with
                          Audio (threshold) pot
```
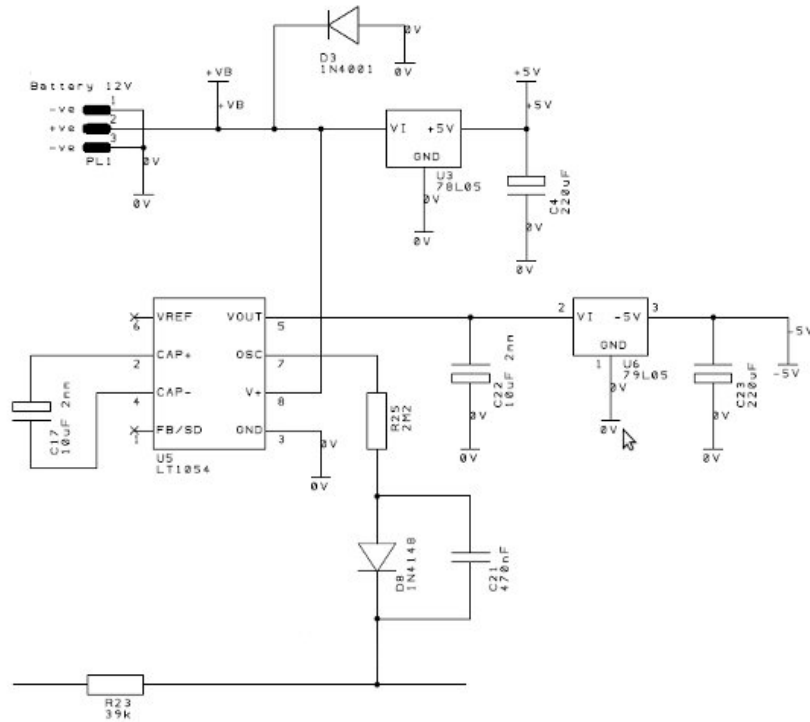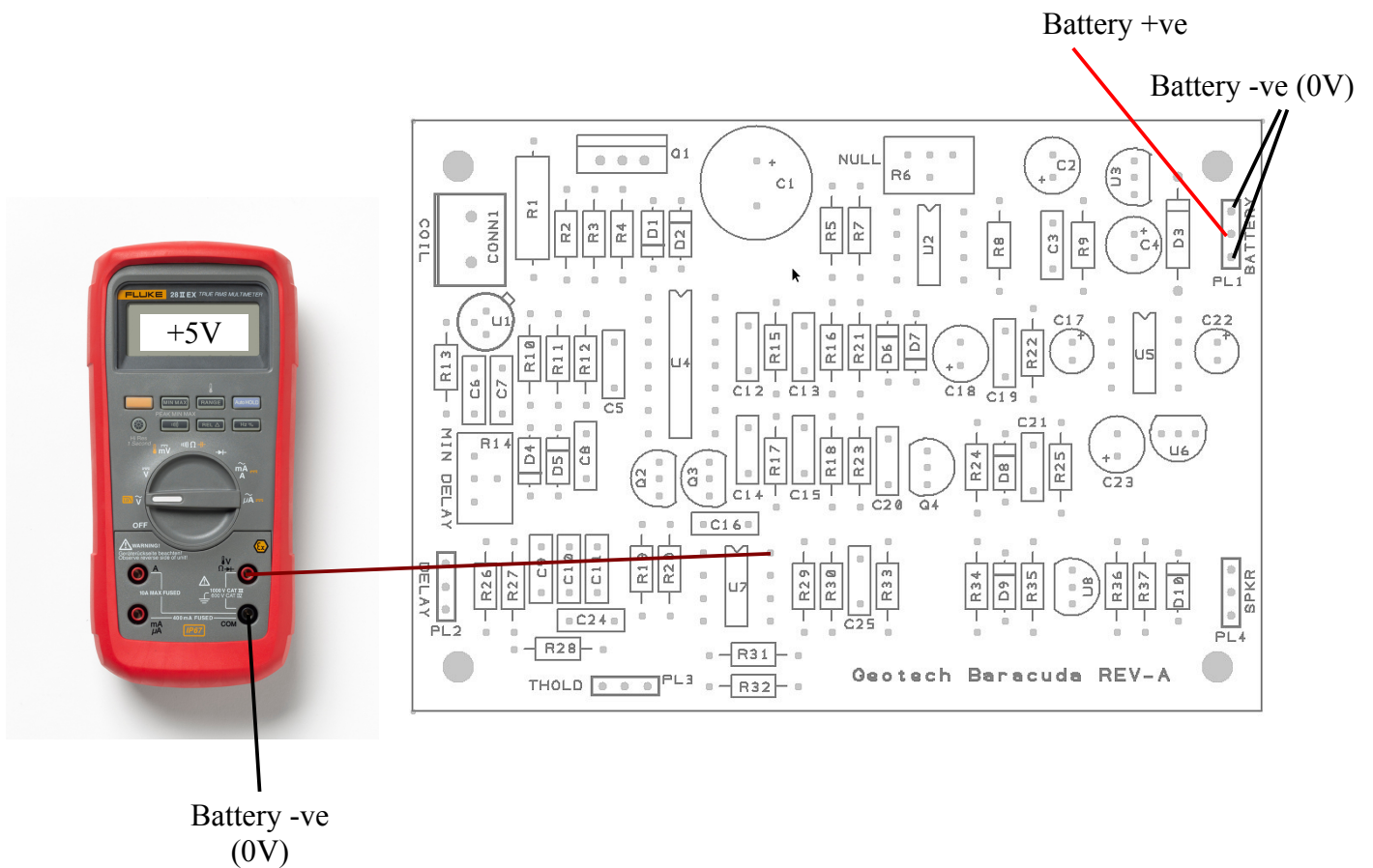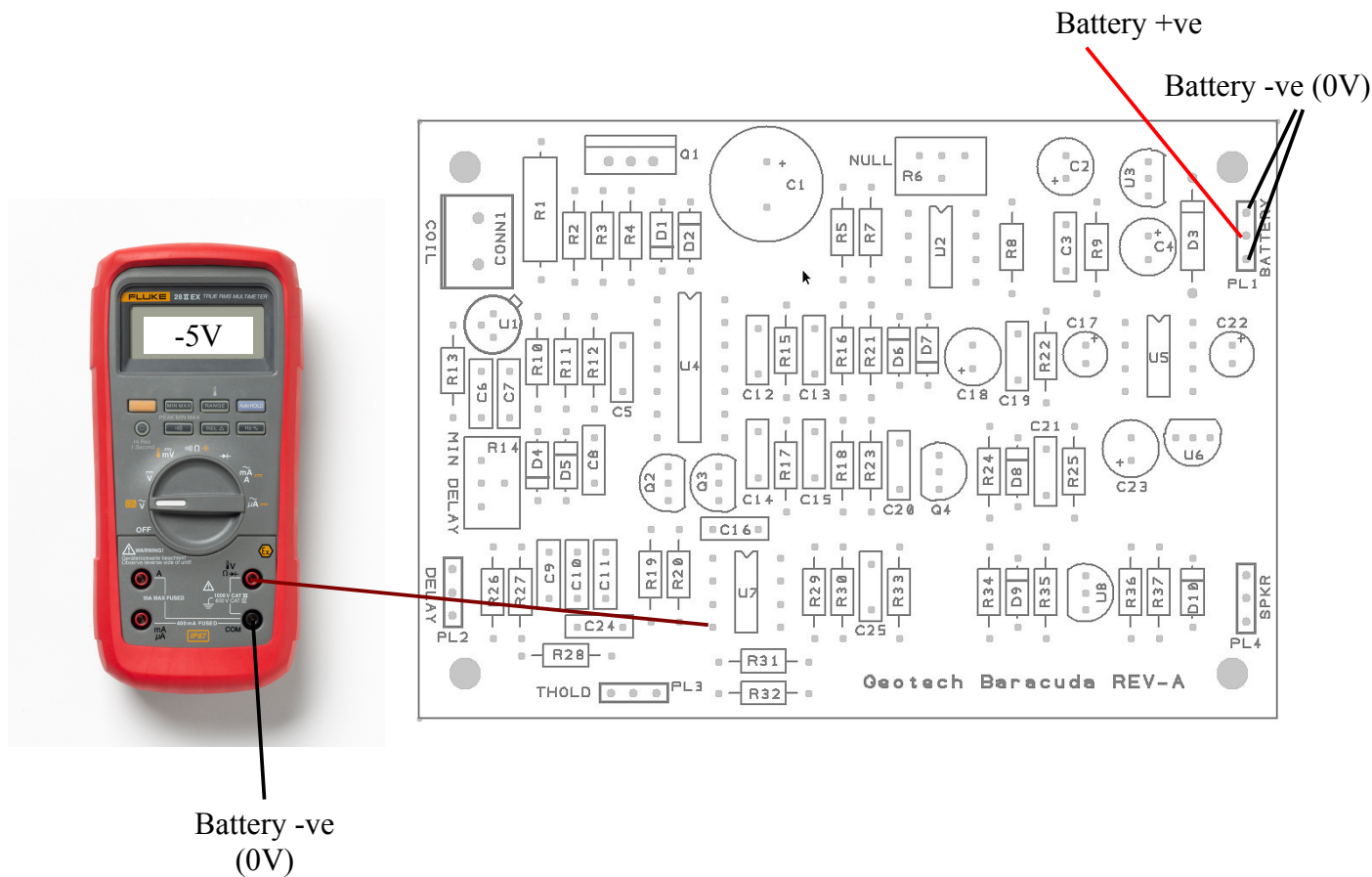
Fig. 1: **Power Supplies**

Fig. 2: **Checking the + 5V Supply**

Fig. 3: **Checking the - 5V Supply**
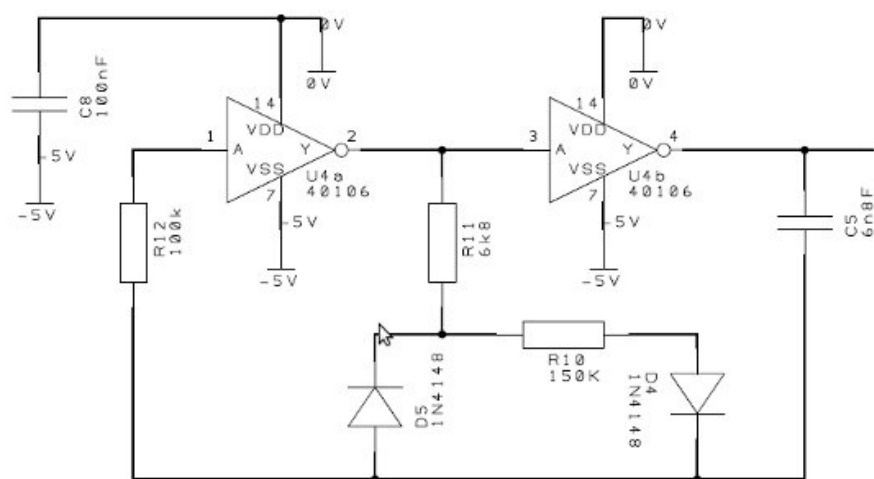
Fig. 4: **Transmit (TX) Oscillator**
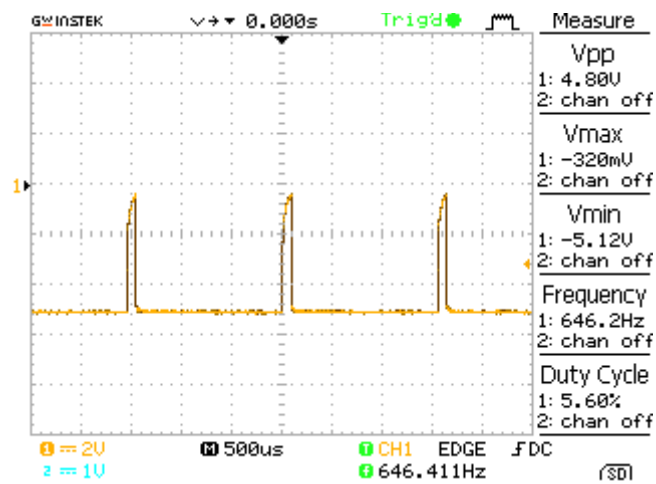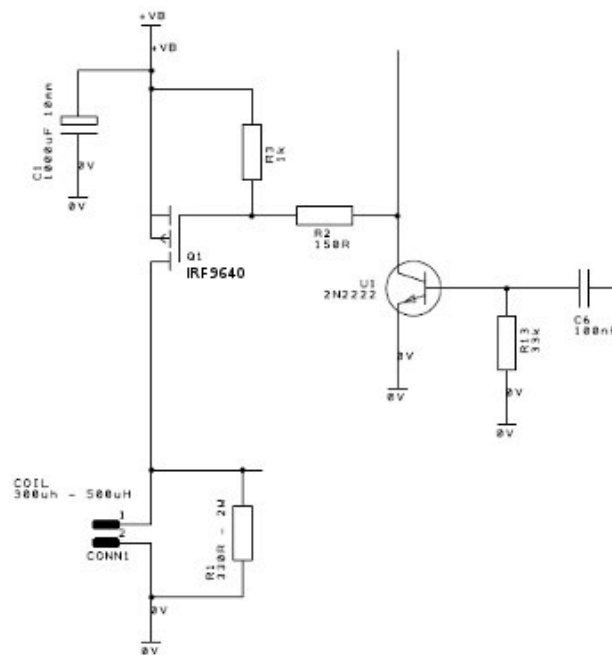
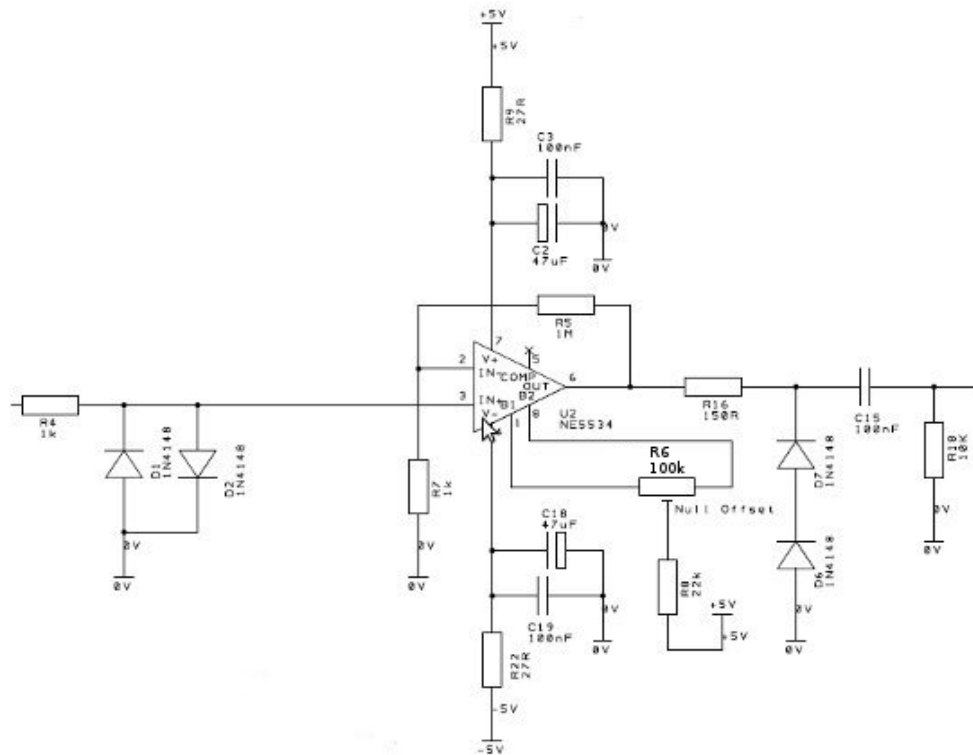Fig. 5: **TX Oscillator Waveform**

Fig. 6: **TX Circuit**
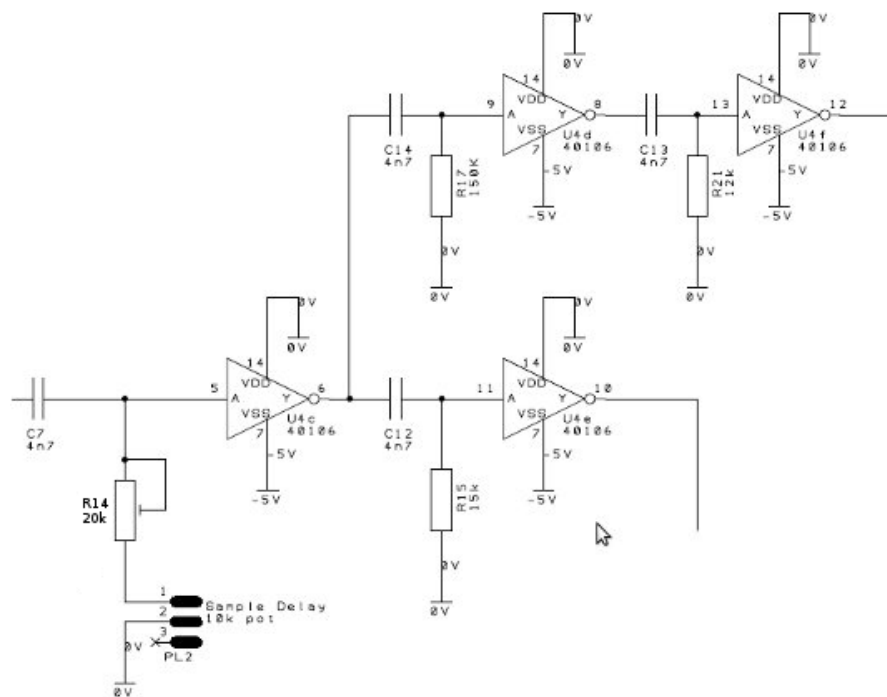
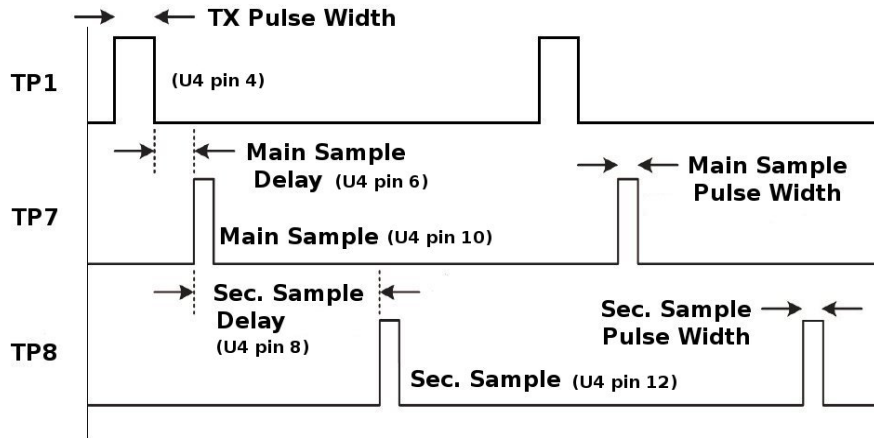Fig. 7: **RX Preamp**

Fig. 8: **Sample Pulse Generator**

Fig. 9: **Sample Timing**

Fig. 10: **Sampling Integrator**

Fig. 11: **Second Integrator**

Fig. 12: **Audio Output Stage**

12V Battery Pack

(via on-off switch)

Screen (0V)
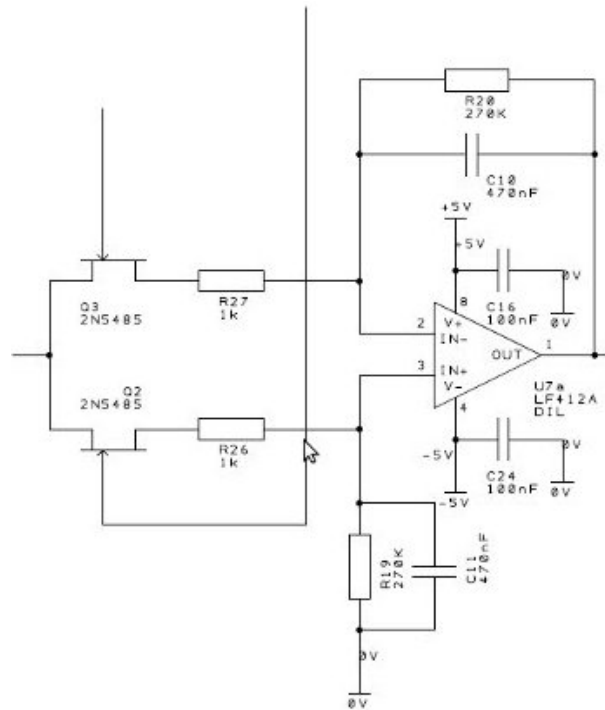
Reject (sample delay) 10k

Audio (threshold)
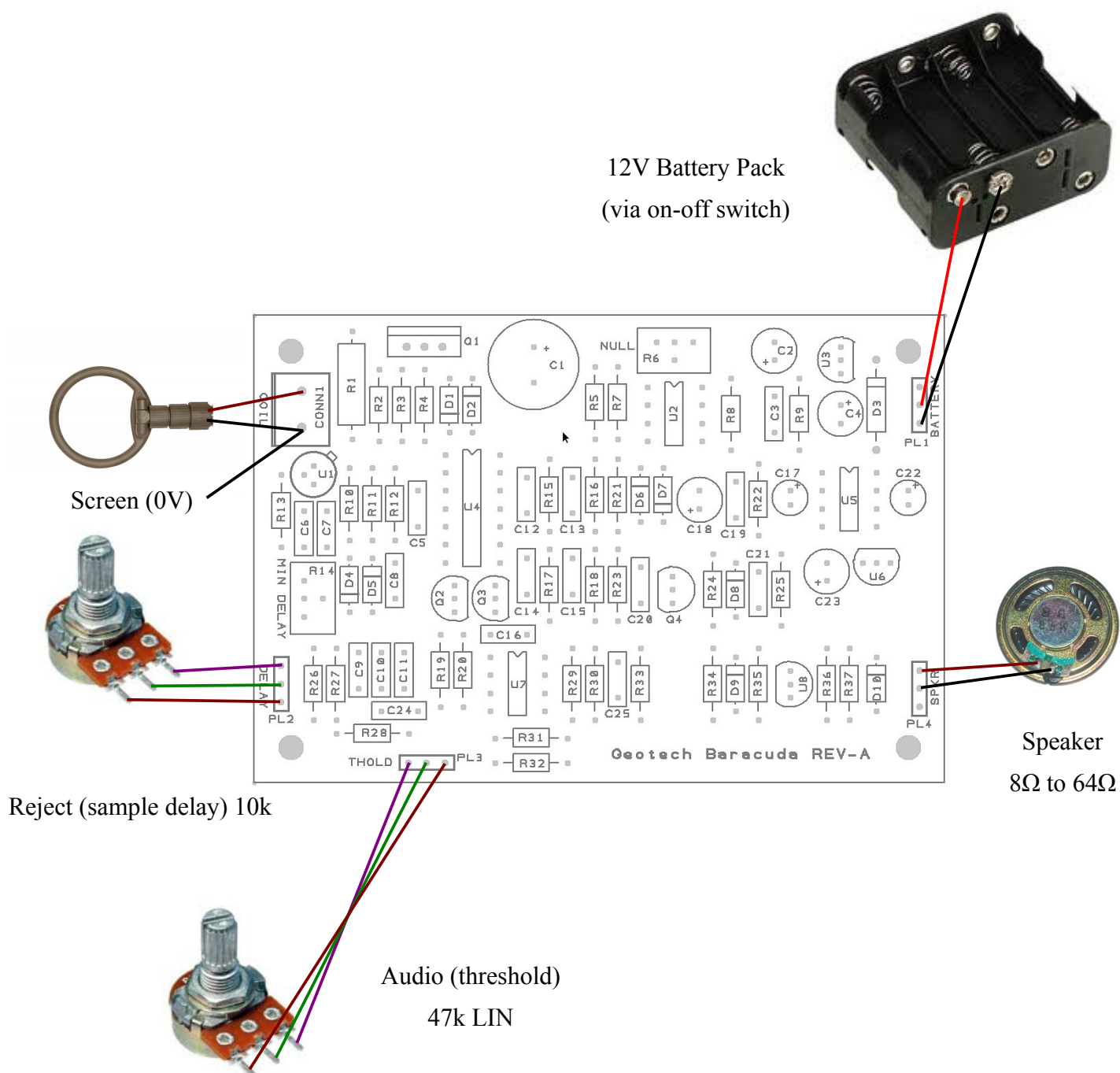
47k LIN

Speaker

8Ω to 64Ω

Fig. 13: **PCB External Connections**

Technical Description

The original Baracuda was designed by John Pugh (lead designer and owner of Anchor Electronics) in the early 1980s. Each detector was hand-built and personally tested by John before leaving the factory. The recommended retail price at the time was $795, which included an 8" search coil, long-handled shaft and NiCd charger. Options were a short-handled shaft (for use when diving) and 11 and 16 inch search coils.

The transmit pulse rate is set at approximately 650pps, with a pulse width of 88us,

Obviously there is no substitute for knowing what you're doing, so here's a brief technical description of the operation of the Geotech Baracuda, which may help you to figure out what's gone wrong … just in case you are unlucky enough to hit a problem.

The power supplies are quite simple. The +5V supply is generated by a linear regulator that is connected across the battery pack. The original schematic showed the battery voltage range to be 8.4V to 12V, but (as previously mentioned) connecting a 12V battery was the cause of component failure in many builds. Following an update to the power supply circuitry, the input voltage range is now 7V to 15V. All voltages and waveforms are referenced to the negative side of the battery. The -5V supply is generated with the help of an LT1054, which is a switched-capacitor voltage converter and regulator. In this design the device is configured as a voltage inverter, which generates a negative voltage that is fed into a linear regulator to create a stable -5V supply.

The LT1054 is synchronized to the TX oscillator, allowing the sampling integrators to eliminate any switching that is introduced into the receive chain. Since the TX oscillator runs at a frequency that is too low to use as an external clock to the voltage converter, the synchronization signal simply inhibits the LT1054's internal clock during the transmit period, and effectively locks the two oscillators together.

In the same way as the original Baracuda, the Geotech version is intended to use a mono coil.

The preamp is a standard single-stage design with a gain of 1000 (60dB). This detector is designed for use on the beach, and (if constructed in a waterproof enclosure) for shallow diving. It is not designed for gold nugget hunting.

There are two samples taken during each receive cycle. The main sample is taken shortly after the TX pulse switches off. Although the minimum sample delay can be adjusted down to 10us, it really needs to be set to about 15us (as a minimum) for use in wet sand. A more practical delay setting would 20us to 25us. This is also long enough for the coil flyback to decay close to 0V, but short enough that eddy currents generated in any nearby metal targets have not completely decayed away. The actual sample delay will depend on the coil being used. Also, the damping resistor (R1) may need to be a different value for different coils in order to provide the critical damping needed (for optimum target sensitivity), and to avoid either an under-damped or over-damped condition. PI detectors are sufficiently sensitive that simply moving the coil through the air will generate a signal at the end of each swing due the Earth's magnetic field. Therefore a second (later) sample is provided, which is subtracted from the main sample. The idea here is that any external signal (such as the Earth's magnetic field) will be present in equal quantities in both samples. Taking the difference between these samples will eliminate the Earth field, leaving the target signal. This is often referred to as EFE (Earth Field Elimination). Due to the way the Baracuda generates the

sample pulses, there is some variation in sample width between the main and EFE samples as the sample delay is adjusted. However, this doesn't appear to produce any real problems in practice.
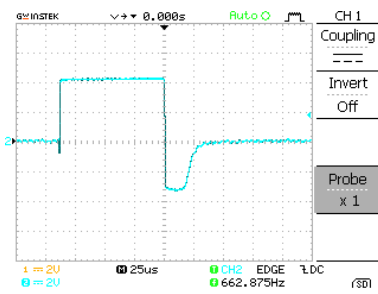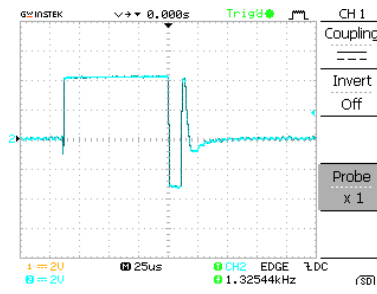

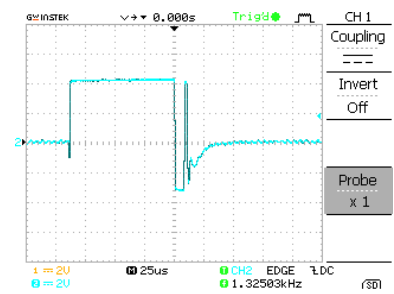Fig. 14: **R$_d$ = 330R**   Fig. 15: **R$_d$ = 470R**   Fig. 16: **R$_d$ = 680R**

Figures 14 to 16 show the output of the preamp versus different values of damping resistor. These examples are for a mono coil with an inductance of 377uH and dc resistance of 1R7. The coil diameter was 22cm and wound with 1mm thickness (including insulation) stranded hookup wire. On other detectors (such as Hammerhead, Surf-PI, and Minipulse Plus) this particular coil can be used with a damping resistor value of 680R, but as you can see from the scope images the best value to use with the Geotech Baracuda is 330R.

The second integrator amplifies the signal further and acts as a low-pass filter, letting through the relatively slow target signals and removing unwanted signals above a few Hertz (cutoff frequency is set at 1.25Hz). The combination of C9 and R29 act as a simple self-adjusting threshold (SAT) which stops the audio output from drifting, removing the need for constant threshold adjustments.

From there, the signal goes through a final integrator stage that provides a threshold adjustment for the audio output. The output of this stage increases the input bias to U8, allowing the audio tone to pass through to either a small speaker or headphones. The closer a metal target gets to the coil, the louder the tone generated at the output. Both the Minipulse Plus [by default] and the Hammerhead [with the VCO option] have a separate oscillator that generates the audio tone, but the Baracuda (and the Surf-PI) use a simpler approach where the TX oscillator is also used to create the audio.

One word of warning. For some inexplicable reason, small (polarity sensitive) piezo speakers will function with a 12V supply even if connected the wrong way round. However, once the battery voltage drops to around 11V, they stop working. If this happens, then check you have the piezo connected correctly.

The above description is just a short technical overview, but hopefully it will help you to understand the detector's operation.

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