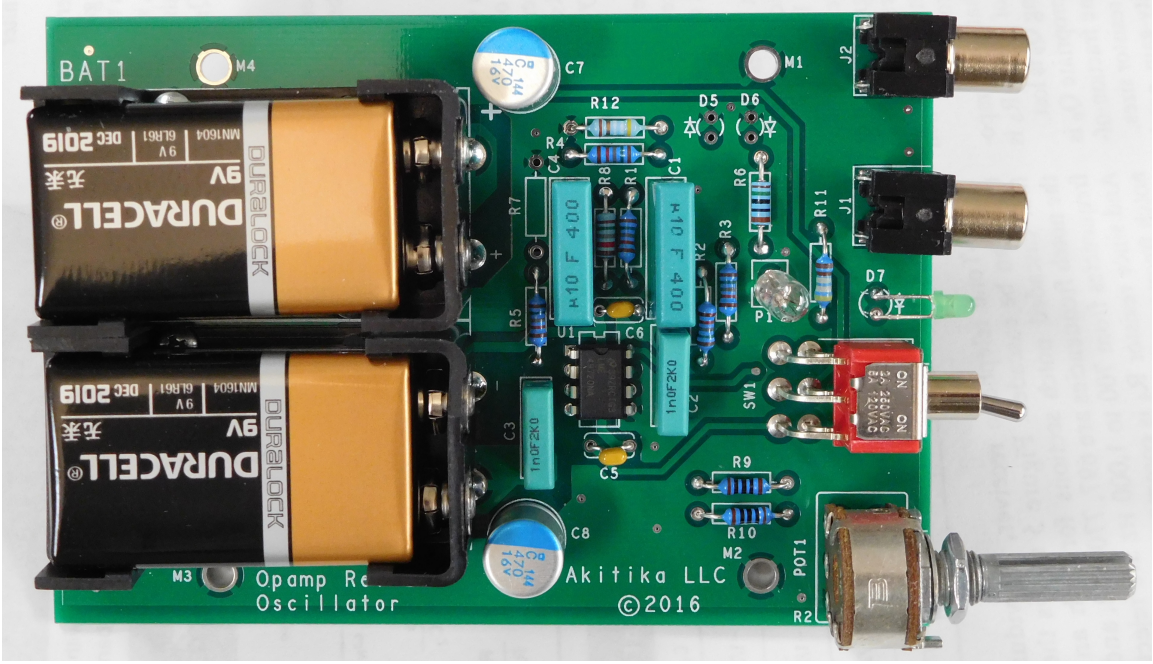
AkitikA



2 PPM Distortion 1 kHz Oscillator
ASSEMBLY MANUAL

(Batteries are not included)

Revision 1p08 April 8, 2024

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Section 1: About This Manual

This manual gives the information needed to build and use Akitika's 2 PPM 1 kHz oscillator. Harmonics are typically more than 114 dB below the fundamental, making the distortion 2 part per million or less. This puts it in the realm of the most expensive, best performing test equipment in existence. It can be used for distortion testing of the highest performing equipment.

It is also very useful as a source for signal tracing. Signal tracing is a powerful technique used to locate the problem in sound reproducing equipment. A signal is placed at the input of the equipment under test (EUT), and its progress is traced through the equipment.

The quickest way to locate the problem is by looking for the signal halfway between the signal source and the desired output. If the signal looks ok halfway through the EUT, then the problem is between the halfway point and the desired output point. If the signal is bad at the halfway point, then the problem is between the source and the halfway point.

In this fashion, you can continue to narrow down the location of the problem. This should lead you to the area of the failed components.

Who Should Attempt this Project?

You can build this kit if you can:

1. Solder (using normal rosin core solder and a soldering iron).
2. Use simple hand tools like screwdrivers, wire cutters, and pliers.
3. Read and follow directions.

It helps if you:

1. know a bit about electronics, or
2. have a friend who knows a bit about electronics,
3. can get to YouTube to watch a few helpful videos about the assembly process (none are posted as of this version of the manual).

Tools you'll need

You'll need the following tools:

1. Phillips screwdriver (#1 and #2)
2. needle nose pliers (helpful, but not strictly necessary)
3. pencil type soldering iron of 25 to 50 Watts (no huge honking soldering guns or blowtorches)
4. wire cutters and strippers
5. multi-meter to confirm resistor values (strongly recommended)!

Helpful Tools

These tools aren't strictly necessary, but they make building the kit easier.

1. Magnifying glass, if you're over 42!

2. Lead bending jig to form axial component leads to the correct span for insertion in the PCB (nice to have, but certainly not necessary).

Project Overview

The project consists of the following steps:

1. Building the circuit board.
2. Installing the circuit board in the housing,
3. Testing the oscillator,
4. Adding the level adjustment resistors

Specifications

Number of Outputs: 2
Output Connector: RCA jacks
Output Impedance: 100 Ohms at Full volume, maximum of 2.5K Ohms at half volume
Frequency: 1000 Hz plus or minus 2%
Amplitude: (maximum volume) 1.5 Volts RMS typical[1]
Distortion: 0.000125% in a bandwidth from 100 Hz to 22 kHz (Zload>600 Ohms)

- 2nd harmonic is -118 dB relative to fundamental (typical)
- 3rd and higher harmonics are significantly more than 120 dB below the fundamental

Power: two 9-volt batteries (not included)
Battery Drain: approximately 10 mA from each battery

Important Safety Notes

By purchasing, using, or assembling this kit, you have agreed to hold Akitika LLC harmless for any injuries you may receive in its assembly and/or use. To prevent injuries:

- Wear safety glasses when soldering or clipping wires to prevent eye injuries.
- Always unplug the power before working on the equipment.
- Large capacitors hold lots of energy for a long time. Before you put your hands into the equipment:
    - Pull the AC plug!
    - Wait 2 full minutes for the capacitors to discharge!
- Remove jewelry and rings from your hands and wrists, or anything that might dangle into the amplifier.
- If working one the equipment with the power on, keep one hand in your pocket, especially if you're near the power supply or power supply wires. This can prevent serious shocks.
- Build with a buddy nearby. If you've ignored all the previous advice, they can dial 911 or get you to the hospital.
- Read and understand the safety manuals of all the tools you use.

[1] Maximum output level depends on your choice of level setting resistor(s).

About Components

We reserve the right to make design and/or component changes at any time without prior notification.

Recommended Solder

The kit must be assembled with 60/40[2] Rosin Core solder. The recommended diameter is 0.031 inches. Among many such sources of solder, I have used Radio Shack part number 64-009. It contains 8 oz. of solder, which is much more than you'll need to assemble the kit.

Warranty

With the exception of fuses, Akitika will replace for free any parts of a correctly assembled kit that fail within one year of the date of purchase when the equipment has been used in home stereo applications. It is the responsibility of the kit builder to install the replacement part(s). This warranty applies to the original purchaser only. It does not apply to units that have been physically or electrically abused, modified without prior factory authorization, or assembled with other than 60/40 Rosin Core solder. Akitika LLC's liability shall in no event exceed the cost paid to Akitika LLC for the kit.

[2] Actually, 63/37 tin/lead solder is ideal. I like Kester 24-6337-8800 50 Activated Rosin Cored Wire Solder Roll, 245 No-Clean, 63/37 Alloy, 0.031" Diameter.

Section 2: About Building the Kit

Yes, I know you want to ignore this section, and jump right into building the kit. However, please ***take a minute and read the advice of this section.*** I've condensed it into bullets so that even you guys who are in a hurry can benefit.

- There is only 1 PCB to build:
- Stop any time you're feeling confused, tired, or anxious. Taking breaks at those strategic times will keep the build enjoyable and greatly enhance your chances of first-time success.
- A soup bowl is your friend. Before you build a board, *carefully* empty the parts into a broad, flat, light colored soup bowl. That makes it easy to find the parts, and keeps them from getting lost.
- A digital ohm-meter is an easy way to make sure that you've picked the right resistor. It's a great cross-check on the resistor color code. Measure twice and solder once!
- A lead-bending jig can make for quicker, neater assembly. It's certainly not necessary.
- Is something in this manual confusing? Does something look wrong? Send your questions by email to dan@akitika.com. You'll help yourself and everyone who builds the kit.

Section 3: Building the PCB

This section details the process of building the circuit board. Begin by *carefully* emptying the contents of the envelope into a broad soup bowl, as shown below. This makes it easy for you to find the components, and much less likely that they will get lost on the floor.

Figure 1-Empty the power supply components into a soup bowl

Component Order

In general, you'll start with the components that lay closest to the board, working your way towards the taller components.

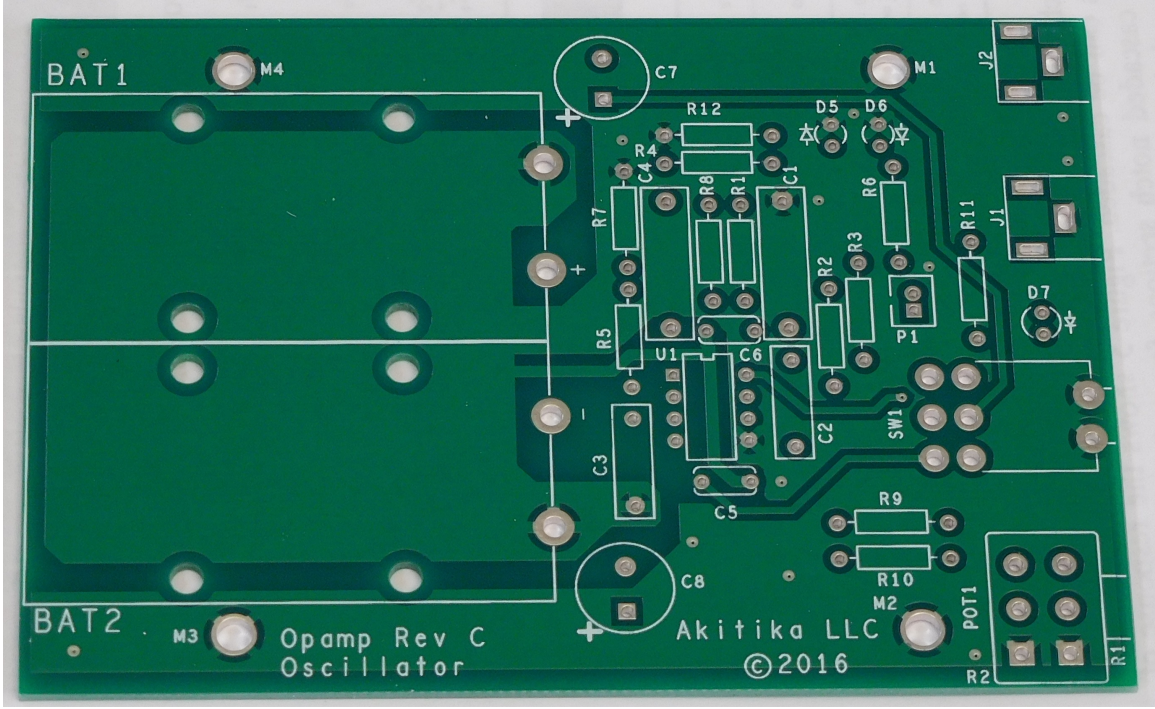

Figure 2-Component side of oscillator PCB before loading

You'll notice that the component designations in the directions don't go exactly in order. We have grouped them so that all components with the same value appear together. This makes assembly easier. You'll find in the parts kit that similar parts, e.g. 3 1K resistors, are typically (though not always) taped together.

Install the Resistors

If you're not sure what resistors look like, or how to read resistor color codes, please refer to Appendix 1.

In general, you install axial leaded components (like the resistors) by placing the body on the silk screen side of the board, and the leads through the indicated holes. Bend the leads over on the back of the board to keep the resistors from falling out until your solder them in place. Try to bend the leads in a direction that won't lead to solder bridges between traces that should remain disconnected.

We recommend the following procedure:

1. Insert all components of the same value or type
2. Bend the leads as described above.
3. Solder the leads on the back of the board.
4. Clip the leads.

Track your progress by placing a checkmark in the done column as you install each component.

Bend resistor leads to 0.45” width			
Designation	Value	Color Code	Done ✓
R10	100	Brown, Black, Black, Black, Brown	
R9	100	Brown, Black, Black, Black, Brown	
R1	15K8	Brown, Green, Gray, Red, Brown	
R2	15K8	Brown, Green, Gray, Red, Brown	
R3	15K8	Brown, Green, Gray, Red, Brown	
R4	15K8	Brown, Green, Gray, Red, Brown	
R5	15K8	Brown, Green, Gray, Red, Brown	
R8	15K8	Brown, Green, Gray, Red, Brown	
R7	--------	Do Not Install, Leave location open	
R11	4K99	Yellow, White, White, Brown, Brown	
R6	150	Brown, Green, Black, Black, Brown	
R12	49.9	Yellow, White, White, Gold, Brown	

Install the Integrated Circuit

Make sure to match the IC’s orientation with the silk screen outline as shown in Figure 3. As received, the rows of IC pins are spread a bit wider than the holes in the PCB. You can bend the pins to the right width by pushing one of the rows of pins against the table.

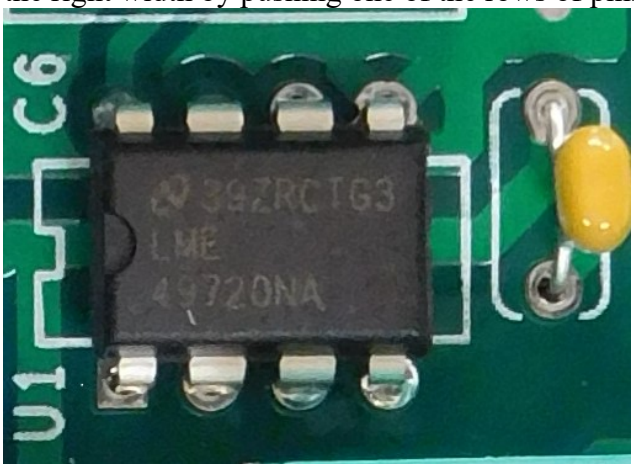

Figure 3-Detail shows correct orientation for U1

Double check the IC orientation before you solder it in place. I like to solder just two corner pins first to make sure that the IC is sitting flat. I then go back and solder the remaining pins.

Orientation matters! Watch pin 1 location carefully.			
U1	LME49720NA	Dual Opamp	

Install the Light Emitting Diodes (LEDs)

Designation	Type	Body type	Done? (✓)
D5	---------	Do Not Install, Leave location open	
D6	---------	Do Not Install, Leave location open	

The last LED, D7, is the pilot light that shows the oscillator has been turned on. It will be installed in the final mechanical assembly section.

Install the non-polarized Capacitors

The capacitors that you install in this section can be installed in either orientation.

Non-Polarized Capacitors			
Designation	Value	Rating, Marking	Done? (✓)
C5	0.1 uF	0.2” lead spacing, ceramic cap, 10%, marked 104	
C6	0.1 uF	0.2” lead spacing, ceramic cap, 10%, marked 104	
C2	1 nF	Box cap, film, 1%, marked 1n0F 2K0	
C3	1 nF	Box cap, film, 1%, marked 1n0F 2K0	
C1	100 nF	Box cap, film, 1%, marked µ10F	
C4	100 nF	Box cap, film, 1%, marked µ10F	

In some kits, C2 and C3 may be axial capacitors, marked “1n 630V +/-1%” as shown in Figure 4.

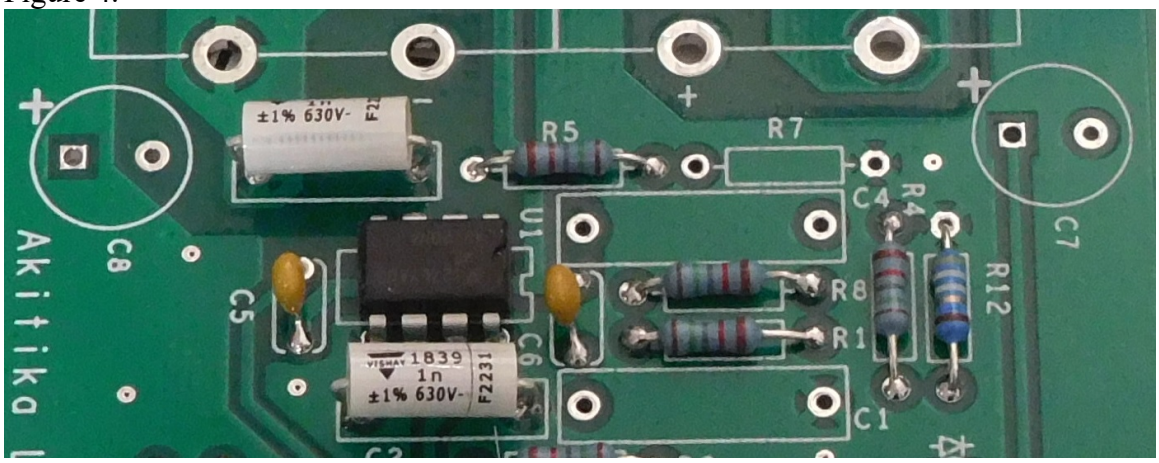

Figure 4-alternate caps for C2 and C3 in some kits

Install the Polarized Capacitors

It’s important to install these caps with the proper polarity. The negative end of the cap is marked with a semi-circle. The silk screen on the board marks where the positive end of the cap goes. Make sure that the semi-circle (negative end of the cap) is away from the plus sign on the circuit board.

Polarized Capacitors – polarity matters!			
Designation	Value	Rating	Done? (✓)
C7	470 µF	16V polymer capacitor	
C8	470 µF	16V polymer capacitor	

Install the Light Bulb

Now install the light bulb (1869D miniature lamp, rated at 14 mA and 10 V) that controls the output amplitude. Solder it into the location marked P1. Either orientation is correct.

Section 4: Final Electrical Assembly and Test

Install the Battery Holders

Install both battery holders as shown in Figure 5.

- Use #4-40x5/16” Phillips screws and 4-40 keps nuts to fasten the battery holders to the PCB. Use a total of 4 screws and 4 nuts as shown in Figure 5.
- Solder the two electrical contacts for each battery holder on the solder side of the PCB. Clip the tails after soldering.

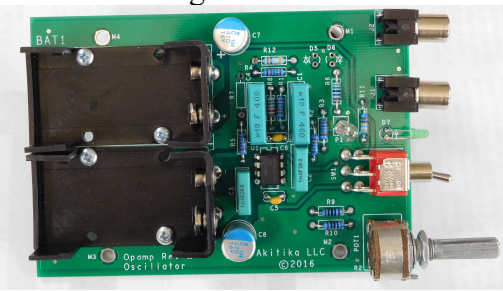

Figure 5-Battery Holder Installation

Front Panel Assembly

- Insert the RCA jacks to the indicated places, J1 and J2, making sure they are also flush against the PCB, then solder them in place.
- Insert the dual 10K volume control to the indicated place,POT1, make sure it is level, then solder it in place. Remove the nut and washer (if supplied). They will not be used.
- Insert the toggle switch to the indicated position, flush against the PCB and solder it on the solder side, as usual.
- Bend LED D7’s leads as shown in Figure 6. Make sure to watch the orientation of the cathode and anode. Insert the diode into the PCB, but don’t solder it yet. Note that the longer of the two uncut leads is the anode (triangle shape).
- Slide the front panel in place, sliding the holes over the controls, connectors, and the still unsoldered D7, with the silk-screened side of the front panel facing out.
- Make sure that the LED pokes into its front panel hole and solder the LED in place. It might be better to solder just one lead, then check and adjust its position before soldering the second lead.

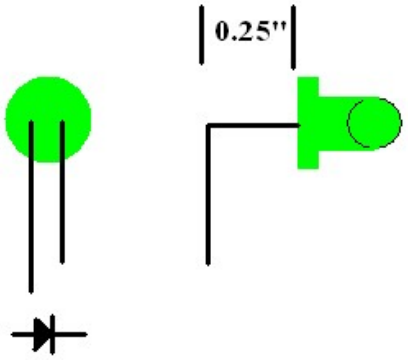

Figure 6-Bending D7's leads

Assembling the Enclosure

1. Place the PCB and front panel into the housing bottom, sliding the front panel into the accompanying grooves in the sides of the bottom half of the housing.
2. Install the four short Phillips 4-20x1/4" plastite screws that hold the PCB to the housing bottom. The housing bottom has two thru-holes through which long screws go that fasten the bottom to the top.

3. Turn the level control to its counterclockwise stop. Place a finger behind the body of the level control while you push the silver knob onto the splined shaft, lining up the knob indicator at the 7 o'clock position.
4. Install a pair of fresh 9-volt batteries (not supplied). Turn the front panel switch on and off to see the LED illuminate. Leave the front panel switch in the OFF position to save the batteries.
5. Install the back panel by sliding it into the channel in the side of the bottom part of the housing. The lightly textured side should face out.
6. Install the housing top. Note that in one orientation it fits well. In the other orientation, projections from the top and bottom will interfere with proper assembly.
7. Install the two long screws into the bottom of the housing that hold the top in place. The screws cut threads into the post as they are installed, which requires some downward pressure on the screwdriver.
8. Turn the oscillator upside down. Peel the rubber bump-ons from their adhesive backing and attach them at four corners on the bottom of the enclosure.

Testing the Oscillator

If you're following the manual closely, the power switch is OFF at this point, and the front panel LED is dark. Turn the power switch on and watch that the LED lights up Turn the volume control counter-clockwise (minimum output). Connect 1 or both RCA jack outputs to any of the following:

- Oscilloscope and/or AC voltmeter
- Power amplifier input.
- High level input on a preamp or integrated amp

Slowly advance the level control and observe or listen to the oscillator output.

Section 5: In case of trouble

Take a break. After you've gained a bit of calm perspective, return to the project. Verify by color-code correct placement of all the resistors. Look closely for unsoldered components, and solder any unsoldered components. Look closely for solder bridges (solder connections that span two points which should be unconnected). Remove the solder bridges. If all of this fails, take well lit, high resolution color pictures of both sides of the PCB and send them to dan@updatemydynaco.com for trouble-shooting advice.

Section 6: About the Oscillator Design

The goal of this design was to make a simple to build, but still state-of-the art oscillator. It provides a variable level, dual channel, signal source for both signal tracing and for distortion measurements. Its distortion is typically around 1 ppm, or about 0.0001%. It puts out 1.5 VRMS, which is sufficient to drive most amplifiers to full output.

The oscillator cascades two relatively high selectivity lowpass filters (Q between 4 and 5). The combination of these two high selectivity filters and light-bulb-based amplitude limiting makes for extraordinarily low distortion. 1% resistors and capacitors are used in the filter/oscillator signal path to assure that the two filter sections have the center frequencies aligned.

Two 9 V batteries power the oscillator. Make sure to install them correctly, as installing the batteries backwards will damage the oscillator. C7 and C8 provide a low impedance for the circuit's power rails at mid-frequencies. C5 and C6 perform that function at high frequencies. R11 and D7 form a pilot light, showing when the power is turned on.

R1, R2, R3, R8, C1, C2, and U1B form an inverting lowpass filter with a gain peak at 1 kHz. R4, R5, C3, C4, and U1A form a non-inverting filter with a gain peak at 1 kHz. Phase shift in those filters caused the feedback taken through R6 to be positive feedback at 1 kHz, enabling oscillator. At DC, the feedback is negative, which assures DC stability for the oscillator. R12 sets the amount of positive feedback to be in a range where the action of the lamp (R13) limits the oscillator output level.

Leveling the oscillator output with a lamp is a technique that dates back to the first oscillators made by Hewlett Packard. The greater the output power, the higher the resistance of the lamp. That decreases the amount of positive feedback, limiting the output amplitude. The level of the oscillator will move around for a few seconds after turn on before it stabilizes. That behavior is normal.

R9 and R10 isolate U1b's output from capacitive loads, ensuring its stability for all conditions. POT1 is a dual 10K audio taper pot that adjusts the output level for both RCA jack outputs to set a useful level for a wide range of applications.

All the filter capacitors have high linearity dielectrics. This helps assure the low distortion performance of the oscillator.

Section 7: Tweaking the Maximum Output Level

For a given surrounding circuit, the maximum output level depends strongly on how the resistance of the lamp varies with the power that it dissipates. The 1869D lamp is relatively consistent within a batch, but the batch-to-batch variation may cause more variation in the output level than we'd like.

The nominal output level (at max volume) is about 1.5 Volts RMS. If the output level is too high then incipient clipping in the output stage may cause unwanted distortion. This typically would happen if the output level gets above 5 Volts RMS.

You can reduce the output level by adding resistance in shunt with R12. The D5 and D6 positions (either or both may be used) are a great place to add a shunt resistance. The lead spacing of D5 and/or D6 will cause you to stand-up mount the resistor. Three resistors have been supplied, 100 Ohms, 150 Ohms, and 200 Ohms.

As an example, something on the order of 150 Ohms drops a 3.4 Volt RMS maximum output to 2 V RMS. But as the EPA used to say, "Your Mileage May Vary". In general, lower values of shunt resistors cause a lower output level. In the limit, you could install the 100, 150 and 200 Ohm resistors in parallel, but that is an unlikely scenario.

Schematics

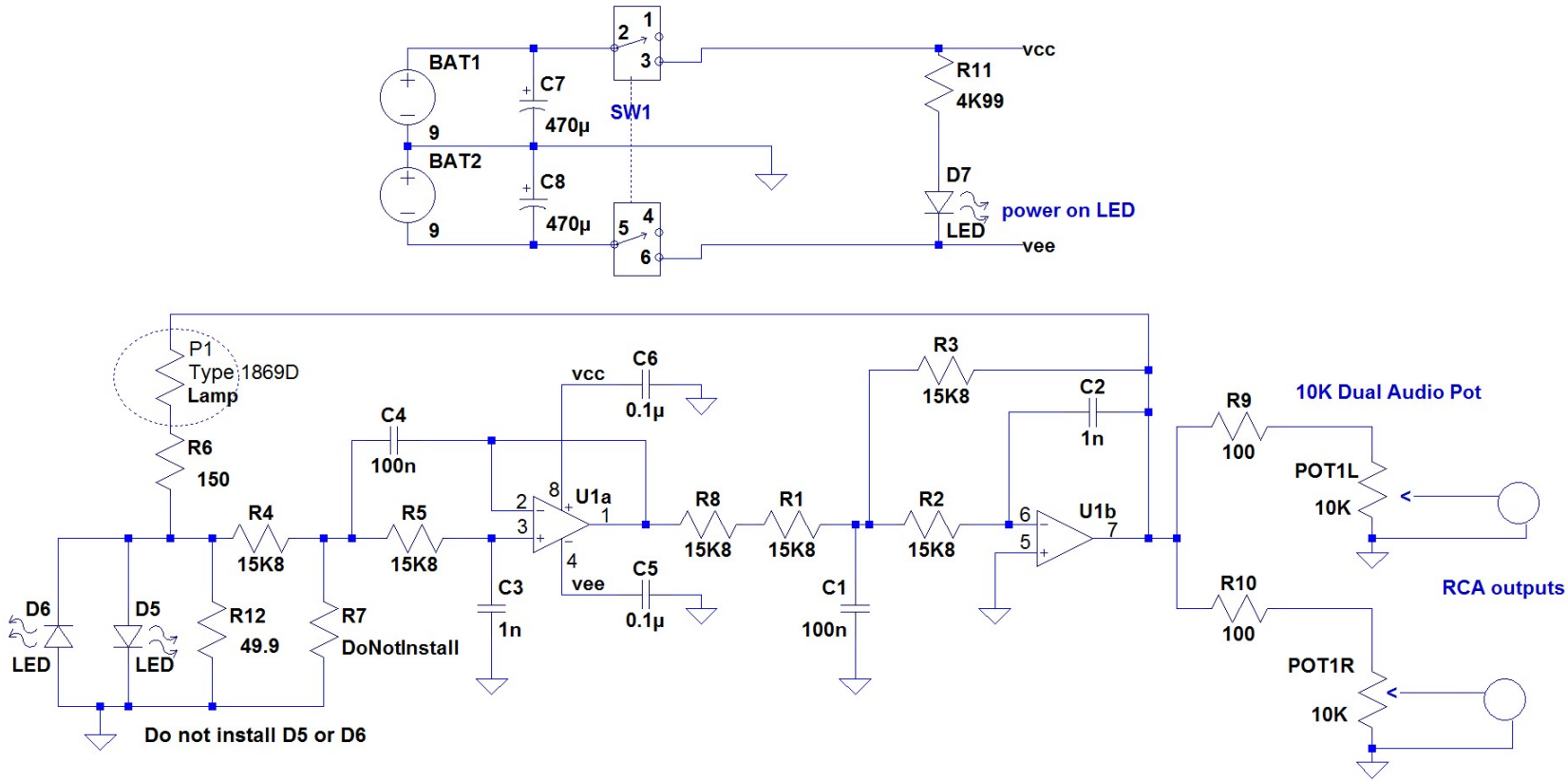

Figure 7- 1 PPM Distortion, 1 kHz Oscillator Schematic

Appendix 1 - Resistor Color Code

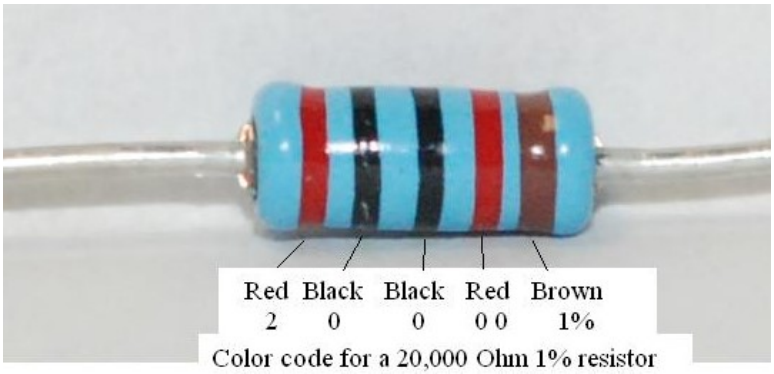

Figure 8-demonstrating the resistor color code

Here's an extreme close-up of a ¼ W metal film 20K (20,000) Ohm resistor, designated by the standard resistor color code.

The colors map to numbers:

Color	Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

The color band positions have the following meaning:

Position	Meaning
1	Left-most Digit (e.g. most significant)
2	Next digit to the right
3	Next digit to the right.
4	Number of zeros that follow the three digits, unless: • Band 4 is gold => multiply by 0.1 • Band 4 is silver=> multiply by 0.01
5	Tolerance: • Violet => 0.1% • Brown =>1% • Red => 2% • Gold=> 5% • Silver=>10%