Soundcard Setup Tester

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1. Introduction

Setting up a PC internal or external soundcard for use with the Radio-SkyPipe charting software can be difficult and confusing in the Windows operating system, partly because of problems with marginally logical and poorly defined nomenclature and partly because of changes made to Windows 7 and Windows 10 in the way they handle audio digital rights management (the problems actually started in Windows Vista).

It is helpful to have a controllable audio signal source that can be connected to the soundcard and used to ensure the PC setup is working as expected. This paper describes an inexpensive audio oscillator and associated circuitry that meets that need (figure 1). This is a simple construction project that may be useful for other purposes. The tester is not used for calibration – it is used only as a test signal source and setup aid and for soundcard troubleshooting. Of course, the audio output from a receiver could be used for this purpose but that is not always convenient.

Some features of the tester are

- Switch selectable Internal 1 kHz or external audio source
- Controllable audio output level
- 3.5 mm stereo and mono output phone jacks
- Switch selectable output – left, right, both
- Switch selectable battery or ac power adapter operation
- Resistive terminations for soundcard inputs

A companion paper provides soundcard and Radio-SkyPipe setup details; see **Soundcard Setup for Radio-SkyPipe** {SCS-RSP}.

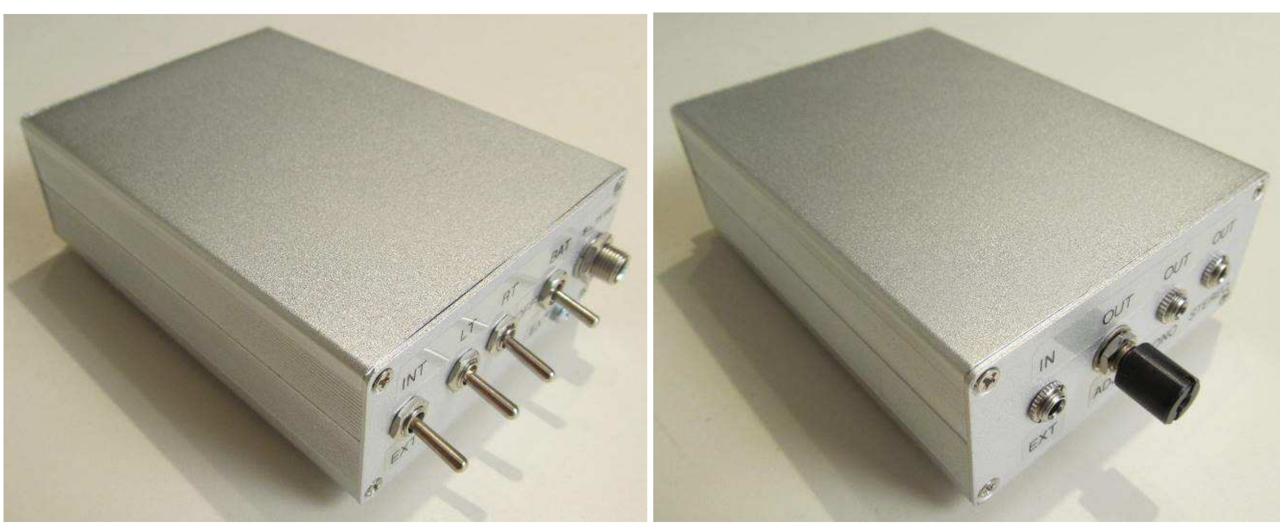

Figure 1 ~ Soundcard Setup Tester completed and ready for use.

2. Audio Oscillator Description

The audio oscillator circuit board used in this project is available as an easy-to-build kit through eBay for about 4 USD (figure 2). It is based on a transistorized Wien bridge oscillator in which a small incandescent lamp is used in the oscillator feedback circuit for automatic gain control (figure 3). The basic circuit theory is described in {Wien}. For this type of oscillator, the frequency is determined by the resistor-capacitor pairs R1, C1 and R2, C2 in the bridge according to

$$f = \frac{1}{2 \cdot \pi \cdot R \cdot C}$$

where f = frequency (Hz), R = R1 = R2 (Ω) and C = C1 = C2 (F).

With the supplied 10 nF capacitors and 15k ohm resistors and assuming perfect components, the theoretical oscillation frequency is 1061 Hz. My unit produced an actual frequency of 1090 Hz or < 3% error. The actual frequency is not important as long as it is audible. The measured maximum no-load output voltage is 1 Vrms at 9 Vdc input (figure 4), and current draw is 16 mA at that input voltage. The output voltage increases as the input voltage is increased but not in proportion. For the application described here, distortion is not an important parameter; however, distortion can be minimized by adjusting the variable feedback resistor R3. The oscillator will stop if the setting is wrong, and the optimum setting for minimum distortion is different for each input voltage. For all measurements given here, I adjusted the feedback resistor for least distortion as subjectively viewed on an oscilloscope.

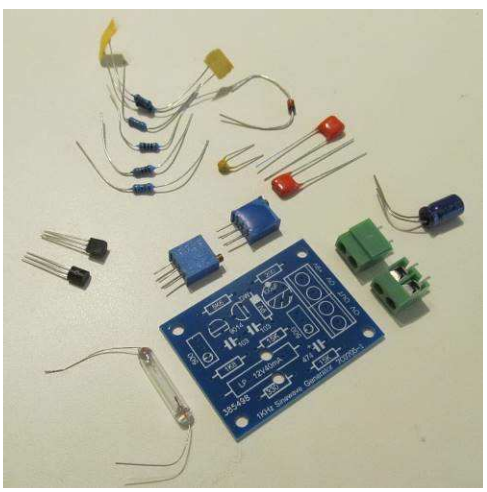

Figure 2 ~ Audio oscillator kit is delivered as a “pile of parts”. A hand-written schematic is shown in the auction but no documentation is otherwise supplied. The printed circuit board is silkscreened with component values, and the kit can be assembled in about 10 min with an ordinary soldering iron. The gain stabilizing lamp is the cylindrical component at lower-left, transistors at the left-middle and trimmer resistors just above the printed circuit board (PCB). The frequency determining capacitors C1 and C2 are the orange components just above and to the right of the trimmer resistors. All components mounted on the PCB are supplied with the kit, but the builder must supply the external components such as enclosure, control switches and phone jacks.

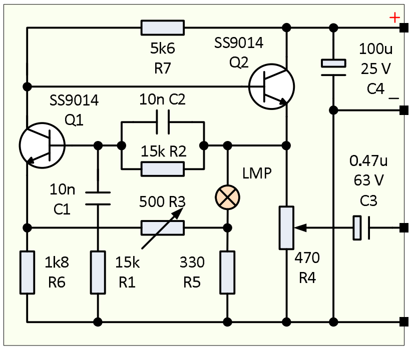

Figure 3 ~ Oscillator schematic. The frequency determining components are R1, R2, C1 and C2. Trimmer resistor R3 is adjusted for reliable oscillation and minimum distortion. Trimmer resistor R4 adjusts the output voltage and is set to maximum in this application. An external potentiometer is used to adjust the completed soundcard tester output level.

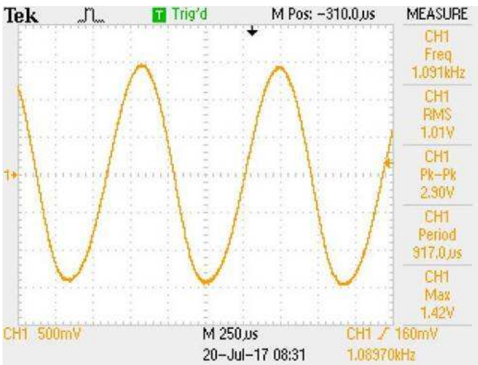

Figure 4 ~ Oscillator output with 9 Vdc input and output trimmer resistor R4 set for maximum. Trimmer resistor R3 has been adjusted for minimum output distortion. Tektronix TDS2022B oscilloscope settings are 500 mV/division vertical scale and 250 µs/division horizontal (time) scale. Some measurements are shown on the right including frequency, rms voltage, peak-peak voltage, period and maximum (maximum 0-peak) voltage. The frequency measurements of this oscilloscope are not particularly accurate.

Determined through experimentation, the minimum input powering voltage for reliable oscillation is about 8.0 V. I tested the oscillator throughout the range 8.0 to 15.0 V. The measured input current and power are plotted for reference (figure 5). At 8, 9, 12 and 15 V input voltages, the corresponding 1 kHz output voltages are 0.5, 1.0, 2.0 and 2.35 Vrms. The oscillator output voltage also depends somewhat on the setting of feedback trimmer resistor R3. For comparison, the output from the Icom R-75 receiver REC OUT jack is 0.35 Vrms.

The oscillator uses two SS9014 NPN epitaxial silicon transistors, which have a maximum collector-emitter breakdown voltage of 45 V. The component with the lowest voltage rating is the power input filter capacitor C4 at 25 V. Although it may be possible to operate this oscillator at input voltages approaching 25 V, there is no reason to use more than 15 V.

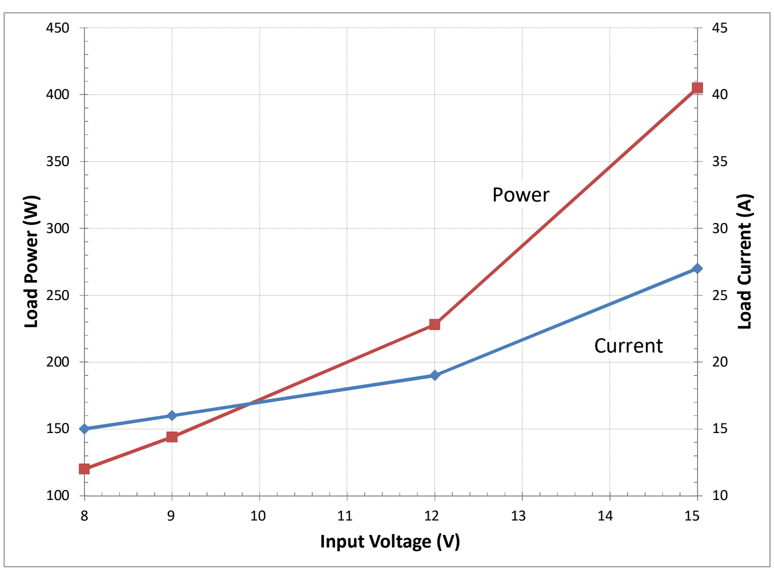

Figure 5 ~ Wien bridge oscillator input power and load current at various input voltages. Measurement points are indicated by markers. Measurements were made with a Keithley 2110 bench digital multimeter and a shop-built current test jig. Power was supplied by an Agilent U80001A dc power supply.

If it is desired to use this oscillator over its full input voltage range with minimum output distortion, an LDO voltage regulator (step-down) or dc-dc converter (step-up or step-down) should be used to control and regulate its input voltage. Power requirements are < 0.2 W, so very low-cost power components may be used. The project described here does not use a voltage regulator or converter. If the oscillator is to be used with a 9 V battery, as it is here, R3 should be adjusted for operation at the minimum reliable operating voltage 8.0 V. If the oscillator is to be used with a regulated ac adapter power supply with, say, 12.0 V output, R3 should be adjusted at that voltage. If it is adjusted for a lower voltage, the only penalty is additional distortion at the higher voltage.

The oscillator output requires a few seconds to stabilize after power is applied as the lamp in the feedback circuit warms up and its resistance changes. The oscillator output is not buffered and can be loaded down by low impedance loads; however, for driving high impedance soundcard inputs as in this project, loading is not a problem.

3. Tester Description

The tester consists of the oscillator previously described, a battery and battery holder, and other components installed in an aluminum enclosure. The tester includes toggle switches for Battery-Off-External power source selection, Left and Right channel On-Off selection, and External-Internal audio source selection, all on the front panel (figure 6). The rear panel holds an output voltage level control and 3.5 mm phone jacks for the External Mono Input source, Stereo output and Mono output. The External-Internal source switch and External input jack may be eliminated if the tester will be used only with the internal source. To conserve battery capacity the tester does not include a power indicating LED.

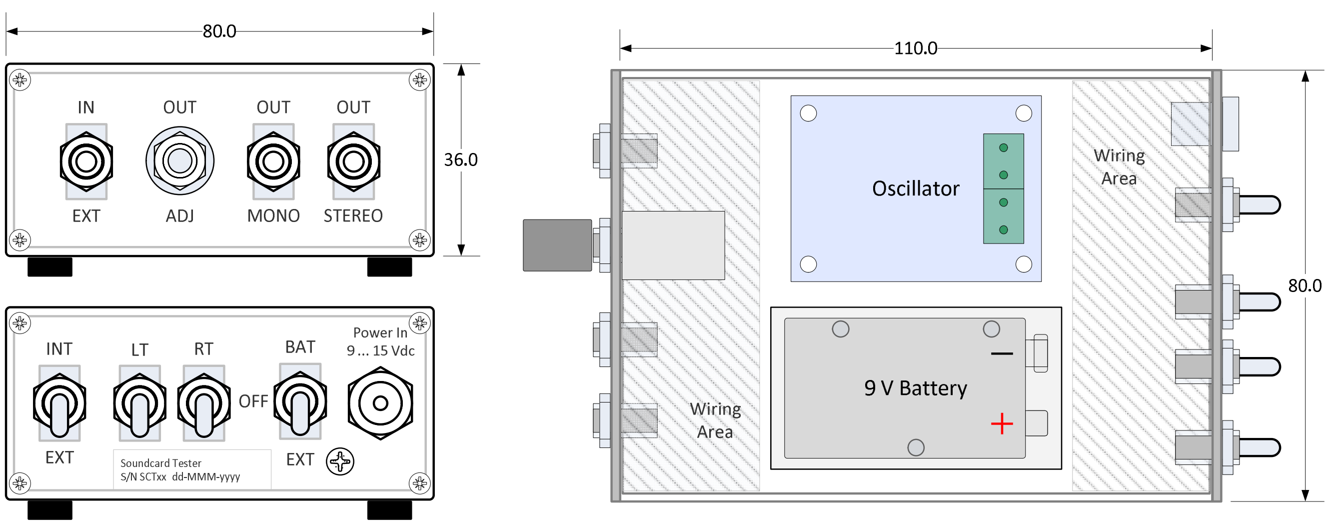

Figure 6 ~ Soundcard Setup Tester layout drawings showing front and rear panels and plan view of interior. These drawings form the basis for full-size drilling templates briefly described in section 5, Construction.

Resistors are used on the left and right output channels to terminate the high impedance soundcard inputs at all times regardless of the output switch positions (figure 7). When the channels are disconnected via the Left and Right switches, the soundcard input termination resistance is 9.1 kohms on each channel and with both channels connected, the load is 4.55 kohms (parallel terminations through switches S3 and S4). The latter resistance is approximately the same as the output impedance on the Icom R-75 REC OUT jack, which is 4.7 kohms.

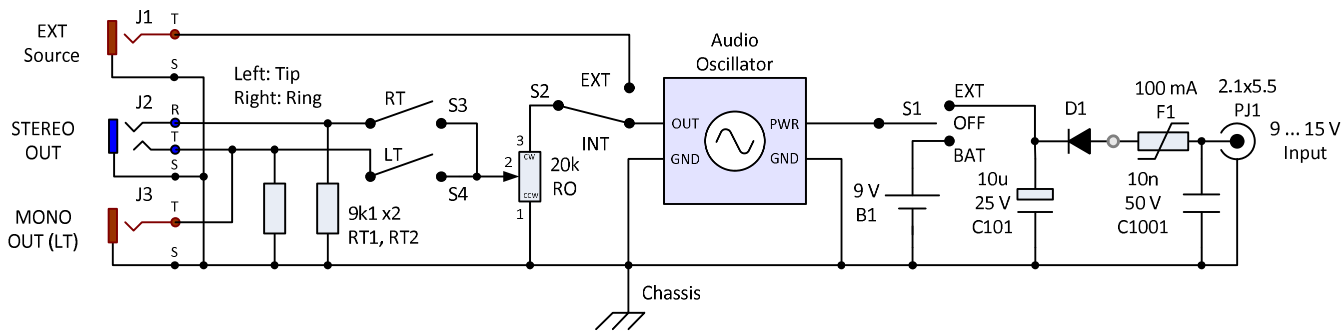

Figure 7 ~ Soundcard Setup Tester schematic. Power components are not critical except they must be able to safely handle the voltages and currents, which in this application are not at all demanding. Note that in the configuration shown, the polarity guard diode D1 protects the oscillator only when an external power supply is used. The diode is not used in the battery circuit because of voltage drop considerations.

With 9 V input to the oscillator, the load current is 16 mA as previously mentioned. Alkaline 9 V batteries (National Electronic Distributors Association, NEDA, designation 1604A) usually have advertised capacity of 500 to 550 mAh but these values apply to a relatively low end-of-discharge voltage of around 5 V, which is far too low for the oscillator used here. The end voltage for proper operation is closer to 7.5 to 8 V, so the usable battery capacity is much lower, perhaps 130 mAh, giving a continuous service time on the order of about 8 h (the actual service time was not measured). The disadvantage of battery operation is that the oscillator feedback resistor will need to be adjusted to ensure operation at the lower battery voltage, which results in distorted output waveforms when operated at higher input voltages from an external source. Fortunately, in this application, even a heavily distorted waveform is of no concern.

The output trimmer resistor on the oscillator PCB, R4, should be adjusted for maximum output. The tester output potentiometer, RO, on the front panel allows output adjustment during operation.

4. Bill of Materials

All components are listed in the bill of material, BOM (table 1). The oscillator and enclosure represent the majority of costs, about 15 USD. I installed the oscillator in an extruded aluminum enclosure with sheet aluminum front and rear panels but a plastic enclosure may be cheaper or easier to work with for some builders.

The power supply input filter capacitors C101 and C1001 are not critical except they should have a voltage rating approximately 1.5 to 2 times the maximum supply voltage. The polarity guard diode D1 should have a low forward voltage drop and usually is a Schottky diode. In this application, minimizing the voltage drop in the battery circuit is a critical requirement so the diode is not used in that part of the circuit; it is used only in the external power circuit where voltage drop is not as much of a concern. If an external ac power adapter rated 12 Vdc is used, the guard diode may be an ordinary power diode, such as a 1N4001 (or any 1N400x diode series). In any case, its current rating should be about 2 times the amplifier current and its reverse voltage rating approximately 2 times the maximum supply voltage. The On-Off switch S1 is necessary for battery operation so I used a center-Off SPDT toggle switch to control both battery and external sources. To minimize the current draw during battery operation a power indicating LED is not equipped. All switches are miniature types and the output adjustment potentiometer RO is a small (0.5 in diameter) 1-turn device.

Table 1 ~ Soundcard Setup Tester material list. The manufacturers, vendor and part numbers are listed as a guide and substitutions may be made based on material on-hand.

Item	Qty	Desig.	P/N	Mfr or Vendor	Description
1	1	-	BOX-2427	RFSupplier	Enclosure, extruded aluminum, 110 x 80 x 36.5 mm
2	1	S1	317244	Jameco	Toggle switch, miniature, SPDT, On-Off-On (center off)
3	1	PJ1	L722A	Switchcraft	DC coaxial power jack, extended barrel, 2.1 x 5.5 mm
4	1	PP1	S760K	Switchcraft	DC coaxial power plug, locking, 2.1 x 5.5 mm
5	1	C1001	545650	Jameco	Capacitor, 10 μF, 35 V, tantalum or electrolytic
6	1	C101	15229	Jameco	Capacitor, 10 nF, 50 V, MLCC
7	1	D1	1N5819	Vishay	Schottky diode, 40 V, 1 A
8	1	F1	MFR-010	Bourns	PTC resettable fuse, 100 ma, 60 V
9	2	-	WH24-xx	NTE	Hookup wire, stranded 7x32, 24 AWG, 300 V PVC, red and black
10	1	B1	1604A	Generic	Battery, 9 V, NEDA 1604A
11	1	B1H	216427	Jameco	Battery holder, 6 in red/black leads
12	1	S2	2135857	Jameco	Toggle switch, miniature, SPDT
13	2	S3, S4	317287	Jameco	Toggle switch, miniature, SPST
14	1	RO	3862C-162-203A	Bourns	Potentiometer, single-turn, Cermet, 1/4 W, 20k
15	2	J1, J3	281834	Jameco	Phone jack, 3.5 mm, mono
16	1	J2	2095437	Jameco	Phone jack, 3.5 mm, stereo
17	2	RT1, RT2	Generic	Generic	Resistor, metal film, 9.1 kohms, 1/4 W
18	4	-	91420A120	McMaster	Machine screw, phillips, pan head, M3 x 5 mm
19	4	-	91106A122	McMaster	Washer, internal star, 3 mm
20	4	-	91169A150	McMaster	Washer, split lock, 3 mm
21	4	-	90592A085	McMaster	Hex nut, M3
22	4	-	Generic	Generic	Standoff, M3 x 6 x 6 mm, male-female, brass
23	4	-	Generic	Generic	Rubber bumper feet, self-adhesive, 6 x 3 mm
24	1	-	7311	Keystone	Terminal lug, double-hole, internal star, #4
25	1	-	783A	USECO	Terminal, double turret, internal thread, 4-40
26	2	-	90272A107	McMaster	Machine screw, phillips pan head, 4-40 x 5/16 in
27	3	-	90272A103	McMaster	Machine screw, phillips pan head, 4-40 x 1/8 in
28	1	-	91102A720	McMaster	Washer, split lock, #4

5. Construction

The layout and construction shown here are based on the extruded aluminum clam-shell enclosure listed in the BOM. I prepared scaled drilling templates in Visio software and printed them on a LaserJet printer (template drawings showing all dimensions are available on request). The templates were cut out and taped to the panels and bottom of the enclosure. After center-punching the hole locations, I cut them with a 1/8 in pilot drill and then a larger drill or step-drill as needed.

After cutting the holes, washing off the cutting oil and cleaning with soap and hot water and 90% solution isopropyl alcohol, I applied the black-on-clear labels. To mount the battery holder, I threaded its three mounting holes with a 4-40 tap and then used 1/8 in long screws to fasten it to the enclosure bottom section (short screws are required so they do not poke the battery). It is easy to strip the soft plastic by over-tightening the screws so I placed a small drop of glue on the screws so they will not loosen. The point-to-point wiring is straight-forward (figures 8). The completed unit is compact but not crowded (figure 9).

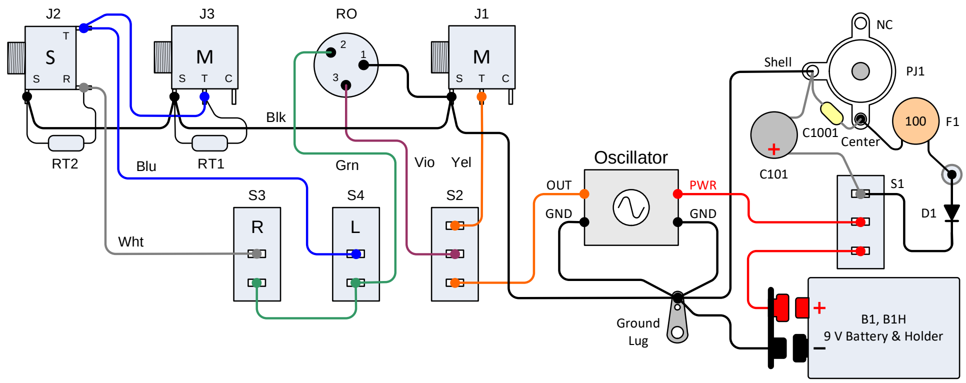

Figure 8 ~ Point-to-point pictorial wiring diagram of front and rear panels, oscillator and battery. The nomenclature shown on the audio jacks is: T=tip, R=ring, S=sleeve, C=contact (not used).

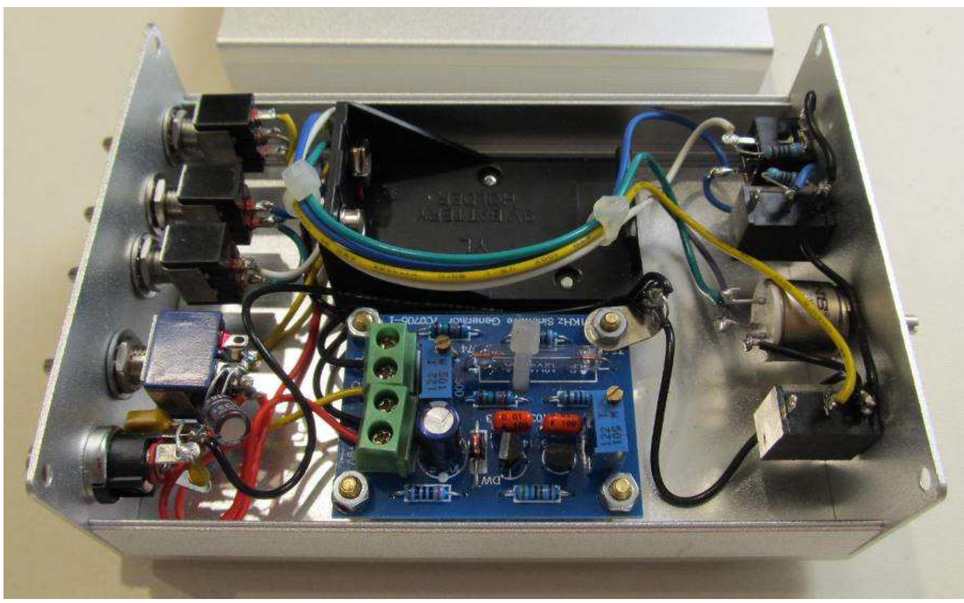

Figure 9 ~ Interior view of completed Soundcard Setup Tester: The oscillator module is at lower-center and 9 V battery holder directly above. The ground lug is attached to the standoff in the upper-right corner of the oscillator PCB. Dimensions are 110 L x 80 W x 36.5 H mm.

6. Testing the Tester

Because the tester is designed to be used as an aid in soundcard setup, I tested it with a soundcard, in this case the internal soundcard in a Windows XP PC. This PC uses the Analog Devices AD1982 chipset and has a stereo Line In jack and a separate Microphone jack. I tested with two different audio cables, one with 3.5 mm stereo plugs and the other with 3.5 mm mono plugs. The soundcard was setup to use the Line In jack (figure 10). I then used the GoldWave audio editor program to record the test activity (figure 11). All switch and control functions through a positive twist in fate worked as expected the first time. The ultimate test was to use the tester on a Windows XP PC with Radio-SkyPipe and this was successful (figure 12). I also used the tester on a Windows 10 PC with a built-in soundcard, Radio-SkyPipe and Argo. I let Radio-SkyPipe run for 12 hours (figure 13) to check long-term output stability. Argo shows very good frequency stability (figure 14).

Figure 10 ~ Analog Devices SoundMAX application that is supplied with the soundcard used in the test PC. For these tests, the Line In jack was used. The Line In Record function seen in the lower section was adjusted to about 25% amplitude and the Balance was set to 50%.

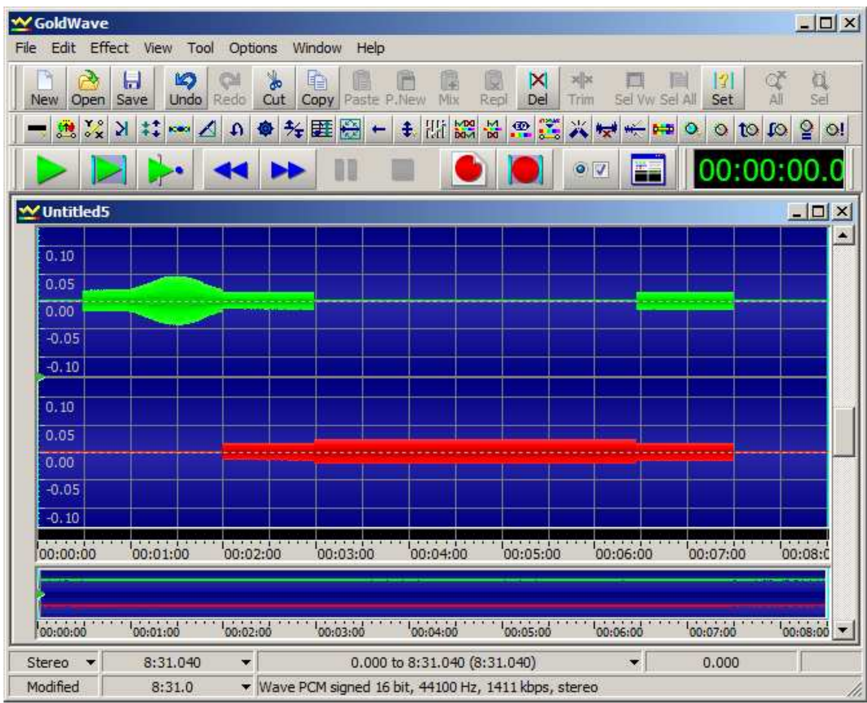

Figure 11 ~ Test sequence recorded by GoldWave. Initially, the display shows no input for 30 s at which time the Left channel was turned On (green trace). The output was slowly increased and decreased. The Right channel was then turned On followed by various Left and Right channel switch actions. Note the amplitude increase in the Right channel at 3 min when the Left channel was turned Off, which reduced the load on the oscillator output. These measurements were made while running on the internal battery.

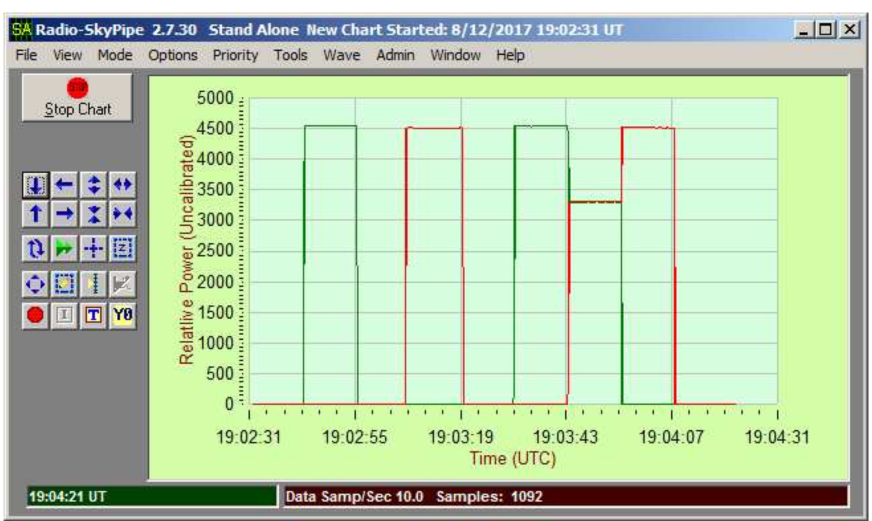

Figure 12 ~ Radio-SkyPipe was setup to use the Left (green trace) and Right (red trace) channels of the PC's internal soundcard. Test sequence:
Both Off: ~12 s
Left On, Right Off: ~12 s
Left Off, Right Off: ~12 s
Left Off, Right On: ~12 s
Left Off, Right Off: ~12 s
Left On, Right Off: ~12 s
Left On, Right On: ~12 s
Left Off, Right On: ~ 12 s
Left Off, Right Off: ~ 12 s
These measurements were made while running on the internal battery.

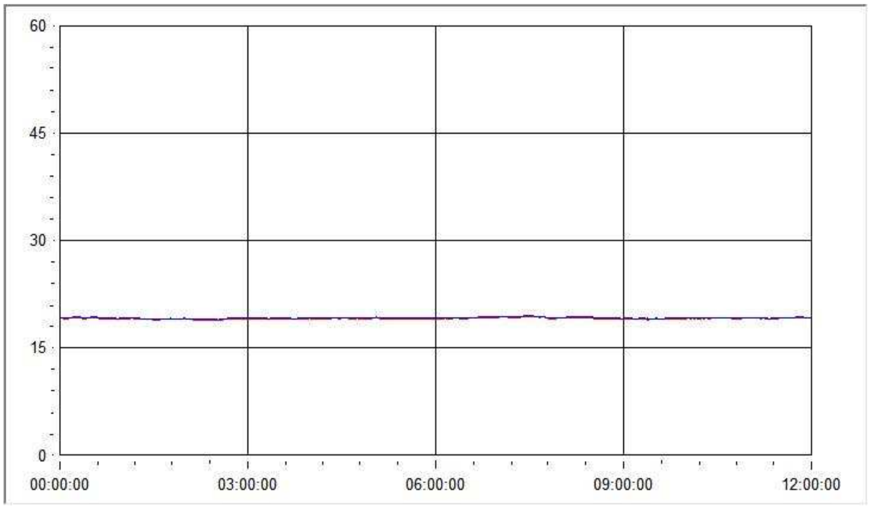

Figure 13 ~ 12-hour run with Radio-SkyPipe shows reasonably good output level stability. Both channels are displayed (red and blue traces) but they are overlaid and show very little difference. These measurements were made while running on an external 12 Vdc regulated power adapter.

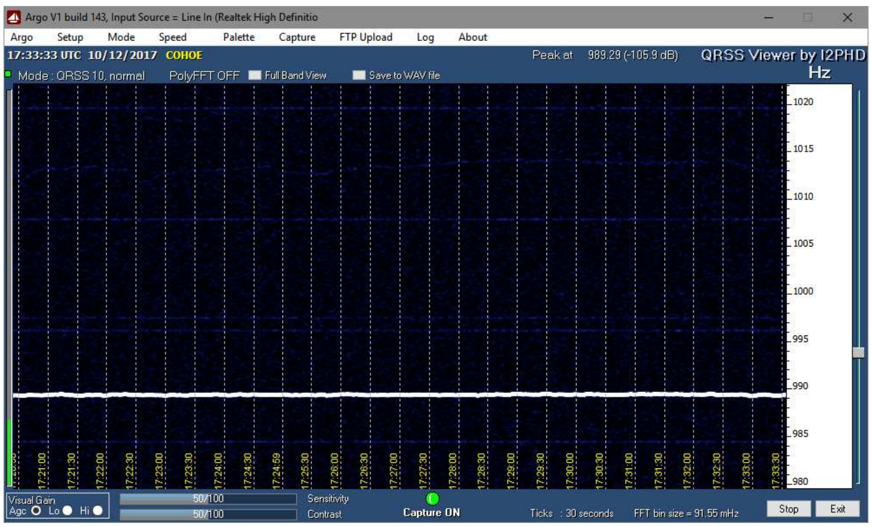

Figure 14 ~ Argo shows a stable output frequency (white horizontal line) of approximately 989.5 Hz over the 13 minute recording. These measurements were made while running on an external 12 Vdc regulated power adapter.

7. Application Notes

1. Typical tester settings and connections for stereo input to soundcard using battery power and internal oscillator:

S1, EXT/BAT:	Battery, BAT
S2, INT/EXT:	Internal source, INT
S3, RT OUT:	Right channel, On/Off as required
S4, LT OUT:	Left channel, On/Off as required
J1, EXT:	External source, no connection
J2, STEREO:	Stereo Output, connect to soundcard Line In with stereo cable
J3, MONO:	Mono Output, no connection
RO, ADJ:	Level adjustment, initially full CCW then adjust as required for test

2. Access the 9 V battery by removing four screws, two on each end panel, and lifting off the upper half of the clam-shell enclosure (note that the enclosure halves are polarized).

3. When installing or replacing the battery be sure the power switch S1 is Off. If On and the battery terminals contact the holder with reverse polarity the oscillator may be damaged.

4. To conserve the battery be careful to turn Off the power switch when the tester is not in use.

5. Use a shielded audio cable with stereo or mono plugs as required by the soundcard configuration to be setup. A stereo plug has tip, ring and sleeve contacts and mono has only tip and sleeve contacts. In some cases it may be necessary to adapt two individual mono circuits to stereo (figure 14). For the 3.5 mm stereo plug, the left channel is the tip and right channel is the ring lead.

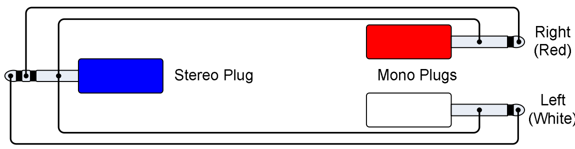

Figure 14 ~ Stereo to Mono adapter cable diagram.

6. The Mono output is activated by the left (LT) channel switch.

7. If using the External microphone input on a laptop be sure it is turned On and the internal microphone, if equipped, is turned Off. Many variations exist so some experimentation or reference to the PC manual may be necessary.

8. With the Soundcard Setup Tester connected to the soundcard, Open Radio-SkyPipe II. In the Options menu, select the Sound tab and then select the desired *Device* and *Input Source*. For complete details, see **Soundcard Setup for Radio-SkyPipe** {SCS-RSP}.

8. References and Web Links

{SCS-RSP} Soundcard Setup for Radio-SkyPipe, available at: http://www.reeve.com/Documents/Articles%20Papers/Reeve_RSPSoundcardSetup.pdf

{Wien} http://www.electronics-tutorials.ws/oscillator/wien_bridge.html

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Document information

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Revision:
- 0.0 (Original draft started, 20 Jul 2017)
- 0.1 (Added schematics, 22 Jul 2017)
- 0.2 (Added images, 08 Aug 2017)
- 0.3 (Completed 1st draft and released as placeholder, 12 Aug 2017)
- 0.4 (Minor edits, 17 Aug 2017)
- 0.5 (Added Argo and RSP 12 h charts, 13 Oct 2017)
- 0.6 (Corrected fig. 6 label, 29 May 2018)

Word count: 3519

File size: 4090880