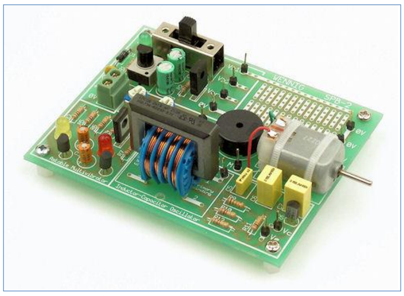
Soldering Projects Board #2 (SPB-2)

Overview, assembly and testing

What does it do?



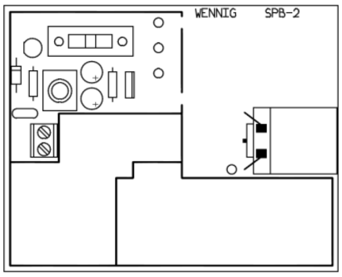
The SPB-2 builds on SPB-1 experience with a range of electronic components and applications, and circuit assembly on a printed circuit board.

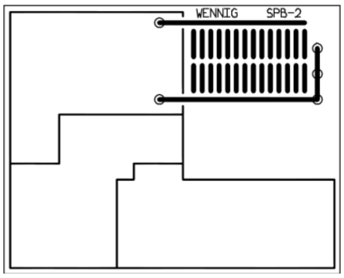
SPB-2 is assembled and tested in small sections – as shown below. Components for three of these sections are provided in two kits:

Kit SPB-2A contains the PCB and components for the DC Supply Control section – including the DC motor
Kit SPB-2B contains components for the Astable Multivibrator and Inductor-Capacitor Oscillator sections – including the piezoelectric transducer.

PCB & DC Supply Control

Kit SPB-2A



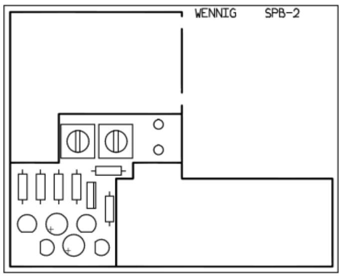


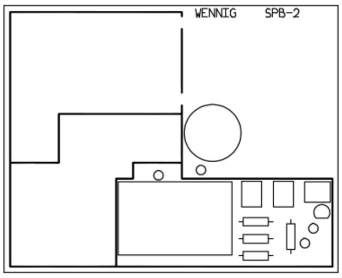
Experimenting Area

(For custom circuits, including ICs)

Astable Multivibrator

Kit SPB-2B





Inductor-Capacitor Oscillator

Kit SPB-2B

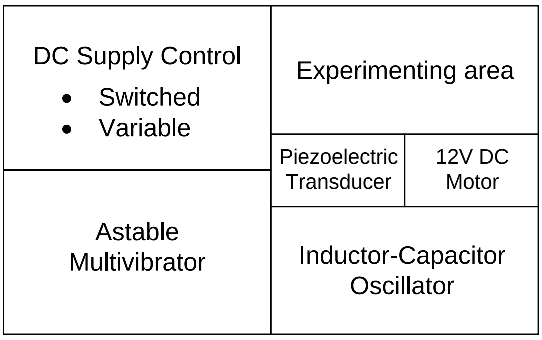
Table of contents

1 Overview

As shown in Figure 1-1, the SPB-2 board is divided into four major circuit sections, with a piezoelectric transducer and 12V DC motor included for connection to those circuits.

The DC Supply Control is usually constructed first, and tested by driving the 12V DC motor. The other circuits can then be individually constructed and powered from the DC Supply Control.

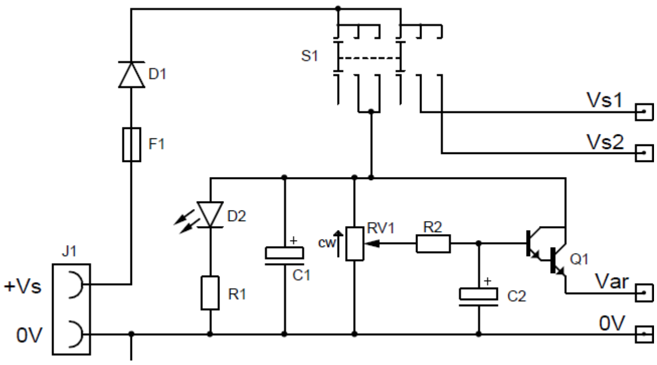
Figure 1-1 SPB-2 circuits



1.1 DC Supply Control

Polyfuse F1 and rectifier diode D1 provide over-current and reverse polarity protection at the DC supply input terminals.

Slide switch S1 connects the protected DC supply to the Vs1 or Vs2 test pins and solder pads. Wire links can then connect these pins or pads to other circuit sections. Green LED D2 illuminates when Vs1 or Vs2 is powered.



Potentiometer RV1 and darlington transistor Q1 provide a variable DC voltage (Var) for general use on or off the board, including the speed control of the 12V DC motor.

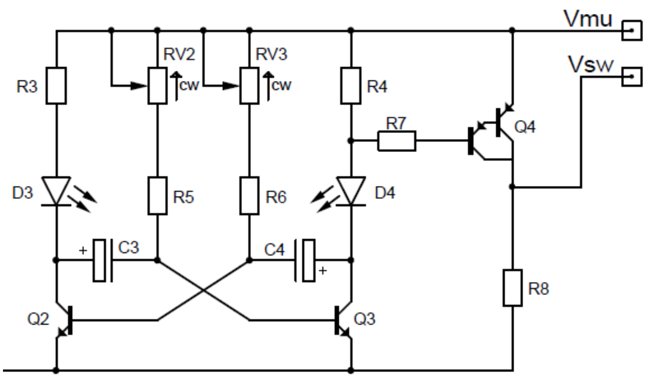
Capacitors C1 and C2, together with resistor R2, reduce the effects of electrical noise produced by the 12V DC motor and the various SPB-2 circuits

1.2 Astable Multivibrator

Cross-coupled transistors Q2 and Q3 alternately switch under the control of timing components RV2, R5, C3, RV3, R6 and C4.

LEDs D3 and D4 illuminate as Q2 and Q3 switch, with current limited by R3 and R4.

RV2 and RV3 enable adjustment of the ON times of Q2 (and D3) and Q3 (and D4).



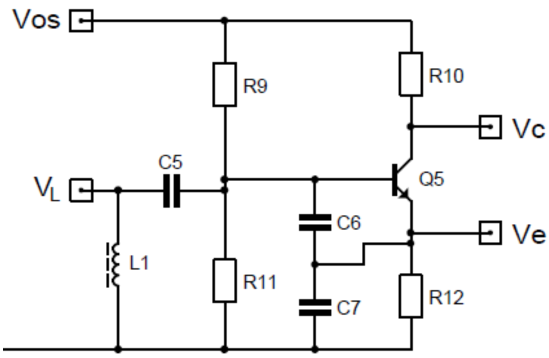
Darlington transistor Q4 electronically switches DC power to external circuits or devices whenever Q3 (and D4) is ON.

1.3 Inductor-Capacitor Oscillator

This circuit produces a sinusoidal voltage waveform at V_L, with a frequency determined by inductor L1 and capacitors C5, C6 and C7.

Transistor Q5 is biased into operation by resistors R9, R10, R11 and R12. The resulting power gain of Q5 overcomes the power loss in the winding resistance of L1, enabling the circuit to oscillate.

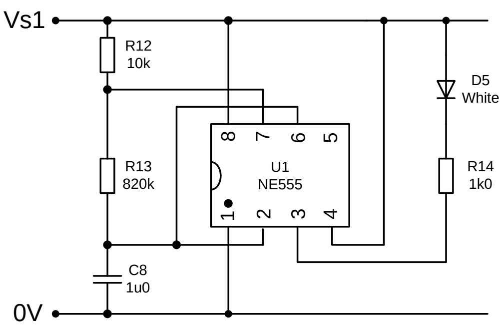
With components chosen to produce an oscillation frequency near 4 kHz, the circuit will audibly drive the piezoelectric transducer P1.

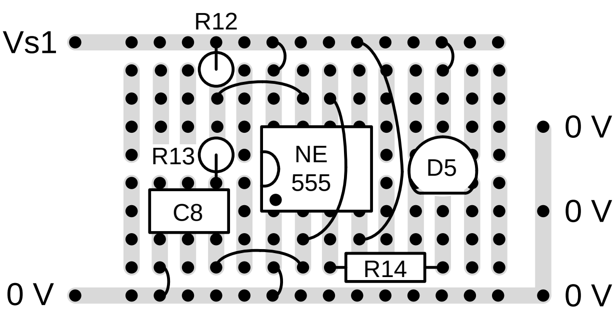


1.4 Experimenting area

This area provides component mounting holes at standard 2.54 mm (0.1 inch) pitch to suit single and dual in-line component packages. Power supply rails provide switched DC to the area, with the upper rail (Vs1) at positive polarity relative to the lower rail (0V).

One example application of this area is an LED flasher using the popular NE555 timer integrated circuit. The following circuit flashes the LED once per second.





2 Assembly guide

Refer also to the parts lists and circuit diagram provided with kits SPB-2A and SPB-2B.

2.1 Before assembly

Wash hands before handling components. Contamination affects solderability and long-term reliability of the assembly.

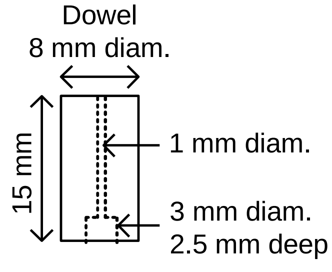
2.2 During assembly

- Wear eye protection, particularly when cropping wires – flying offcuts injure eyes
- There are no static-sensitive components in the SPB-2 kits, but it is always wise to use a wrist-strap and anti-static mat (or equivalent anti-static practices) when handling semiconductors
- When bending the lead-wire of a component, grip the wire with small pliers and bend the **free end** of the wire – so the pliers isolate the component package from bending forces
- After loading wire-leaded components onto the PCB, semi-clinch (45° bend) and crop the wires to about 1.5mm from the board surface
- Use a fume extractor when soldering.

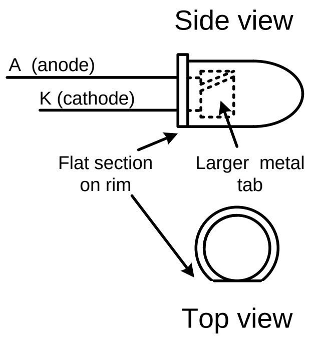
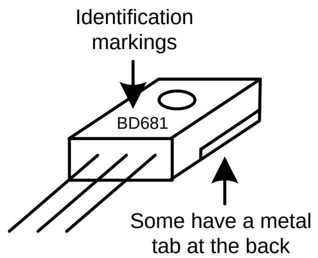
2.3 DC Supply Control – suggested assembly sequence

<table>
<tr><th>Component</th><th>Comment</th></tr>
<tr><td>Test-pins at
Vs1,
Vs2,
Var,
0 V (x4)
and
M (motor)</td><td>
Test-pins provide convenient connection points for wire links and meters. They can be added at any time, but it is easier to hold these pins in place while soldering if they are loaded before any taller components.

Separate the 8 test-pins with diagonal cutters
Insert each test pin into the PCB, and hold it in place with a pad of plastic foam or a wooden test-pin support block (see below) while soldering. If using plastic foam, keep the soldering time short to minimise heat damage to the foam.

Test-pin support block
Cut a 15 mm length of 8 mm diameter (or similar) dowel, and drill a 1 mm diameter hole through the axis as shown in this sketch. This can be used to hold the pin in place with a finger while soldering.
If a 3 mm clearance hole for the plastic block on the pin is included, the support block can touch the PCB surface and hold the pin perpendicular to the PCB while soldering.


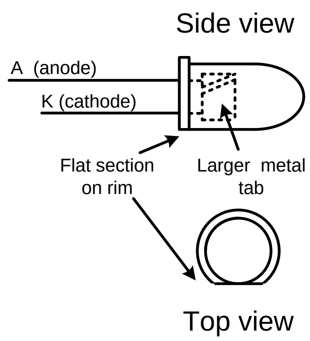
</td></tr>
</table>

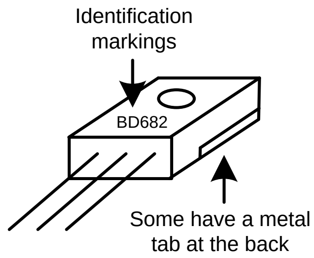
R1, R2	Resistors are not polarity sensitive, but for ease of reading their colour codes, install them with their gold tolerance bands toward the top edge of the PCB
D1	Diodes are polarity sensitive, so check orientation before installing – the cathode band on the diode should align with that on the diode outline on the PCB
F1	Polyfuses are not polarity sensitive, so can be installed either way around. The polyfuse will become very hot when activated, so should be positioned about 5mm clear of the PCB surface. If there are pre-formed bends in the lead wires, let them determine the clearance from the board
D2	LEDs are polarity sensitive, so check orientation before installing – align the 'flat' section on the LED rim (nearest the cathode lead) with that on the LED outline on the PCB 
RV1	Position the pins and mounting tabs over the holes in the PCB, and squeeze the metal sides of the package while pushing firmly downward. The sprung mounting tabs 'snap' into the mounting holes, locking the package in place. Little solder is required on the mounting tabs – outside edges only.
C1, C2	Electrolytic capacitors are polarity sensitive, so insert the positive polarity lead-wires (usually the longer lead) into the holes marked '+', and negative polarity lead-wires (nearest the negative '-' mark on the side of the capacitor body) into the unmarked holes.
Q1	Transistors are polarity sensitive. Ensure that the side with identification markings faces toward resistor R2 
S1	• This switch is a firm press fit into the board. Check pin alignment with PCB holes before applying pressure • The switch connections and mounting pins are quite thick, requiring plenty of heat to solder. Flux will help the solder flow
J1	Check orientation before installing – wire access holes must face outward

M1	• Secure the motor to the PCB with the two cable ties • Solder single-strand connecting wires between the terminals on the motor and the two holes provided on the PCB
Flexible link-cables	To supply power to the other sections of the SPB-2, or to drive the DC motor, link-cables are needed. • Connect a crimp contact to each end of one 100 mm flexible cable. This connection can be made with a crimping tool or pliers, or can be soldered. • Cut the 80 mm length of heat-shrink tubing into four 20 mm pieces, and slide two pieces over the crimped (or soldered) joints and connectors, leaving about 1 mm of the open ends of the connectors exposed • Shrink the tubing onto the cable and connectors with a hot-air gun • Assemble a second link-cable with the remaining components

Test the assembly using the **Test Procedure** for the **DC Supply Control** (see Topic 3)

2.4 Astable Multivibrator – suggested assembly sequence

Component	Comment
Test-pins at Vmu, Vsw	• Separate the test-pins with diagonal cutters, and insert them into the PCB • Hold the pins in place with a pad of plastic foam or pliers while soldering
RV2, RV3	Two different pin configurations are provided for on the PCB, so choose the appropriate mounting holes for the trimmer potentiometers provided in the kit
R3 – R8	Resistors are not polarity sensitive, but for ease of reading their colour codes, install them with their gold tolerance bands toward the top edge or the right-hand side edge of the PCB
D3, D4	LEDs are polarity sensitive. Align the ‘flat’ sections on the LED rims (nearest the cathode leads) with the flat sections on the D3 and D4 outlines on the PCB 

Q1, Q2	• Transistors are polarity sensitive. Align the flat surfaces on the transistor bodies with the flat sections on the Q1 and Q2 outlines on the PCB • Gently bend the transistor leads to suit the hole spacing • Before soldering in place, ease the transistors down until there is about 2 mm clearance between the transistor bodies and the PCB
C3, C4	Electrolytic capacitors are polarity sensitive. Iinsert the positive polarity lead-wires (usually the longer lead) into the holes marked '+', and negative polarity lead-wires (nearest the negative '-' mark on the side of capacitor body) into the unmarked holes.
Q4	Transistors are polarity sensitive. Ensure that the side with identification markings faces toward resistor R4 
Flexible link-cables	To power the multivibrator from the DC Supply Control, and to drive devices such as the DC motor, link-cables are needed. • Connect a crimp contact to each end of one 100 mm flexible cable. This connection can be made with a crimping tool or pliers, or can be soldered. • Cut the 80 mm length of heat-shrink tubing into four 20 mm pieces, and slide two pieces over the crimped (or soldered) joints and connectors, leaving about 1 mm of the open ends of the connectors exposed • Shrink the tubing onto the cable and connectors with a hot-air gun • Assemble a second link-cable with the remaining components

Test the assembly using the **Test Procedure** for the **Astable Multivibrator** (see Topic 3)

2.5 Inductor-Capacitor Oscillator – suggested sequence

Component	**Comment**
Test-pins at Vos, P, V_L, Vc and Ve. (optionally at L1 pads 3 and 4)	• Separate the test-pins with diagonal cutters, and insert them into the PCB • Hold the pins in place with a pad of plastic foam or pliers while soldering • If the primary winding of a transformer is used for L1, transformer action can be studied by observing the waveform on the secondary winding. Additional test-pins are provided to give access to this secondary winding

R9 – R12	Resistors are not polarity sensitive, but for ease of reading their colour codes, install them with their gold tolerance bands toward the top edge or the right-hand side edge of the PCB
Q5	• Transistors are polarity sensitive. Align the flat surface on the transistor body with the flat section on the Q5 outline on the PCB • Gently bend the transistor leads to suit the hole spacing • Before soldering in place, ease the transistor down until there is about 2 mm clearance between the transistor body and the PCB
C5 – C7	Polyester capacitors are not polarity sensitive, but it is good practice to position them for ease of reading their value codes
L1	If an inductor is installed here, it must be connected between pads 1 and 2. A cable tie through the holes provided in the PCB can be used to hold the inductor in place If a transformer is installed here, the inductance of the winding connected between pads 1 and 2 will determine the oscillation frequency. If the primary and secondary windings have the same number of turns, the transformer can be installed either way around. If the turns differ however, the orientation of the transformer will influence the oscillation frequency
P1	The piezoelectric transducer is not polarity sensitive, so can be installed either way around
Flexible link-cables	To power the oscillator from the DC Supply Control, and to drive devices such as the piezoelectric transducer, link-cables are needed. • Connect a crimp contact to each end of one 100 mm flexible cable. This connection can be made with a crimping tool or pliers, or can be soldered. • Cut the 80 mm length of heat-shrink tubing into four 20 mm pieces, and slide two pieces over the crimped (or soldered) joints and connectors, leaving about 1 mm of the open ends of the connectors exposed • Shrink the tubing onto the cable and connectors with a hot-air gun • Assemble a second link-cable with the remaining components

After assembly

- In a well ventilated area, clean resin from the completed assembly with isopropyl alcohol and a small flux brush
- Buff the soldered side of the cleaned assembly with a clean, stiff-bristled paint brush - a 25 mm wide paint brush with bristles cut back to about 20 mm length is ideal
- Visually inspect all solder joints, and re-work / re-clean where necessary
- Wash hands to remove resin and solder residues.

3 Basic test procedure

Take the actions, and make the observations listed in the following tables. Where a circuit does not behave as suggested in the tables, check the assembly for solder joint integrity, correct component values, and correct component orientation on the PCB.

3.1 Additional equipment required

- 1 x 9 V PP3 battery (or a DC power supply with an output voltage between 6 V and 15 V)
- Small screwdrivers (Phillips head and blade)

3.2 DC Supply Control section

Check the switched DC outputs (Vs1 and Vs2) using the 12V DC motor

Actions	Observations
1. Adjust switch S1 to the left-most (OFF) position 2. Rotate RV1 fully anti-clockwise (OFF) 3. Connect a link-cable from test-pin Vs1 (switched DC output #1) to test-pin M (DC motor) 4. Connect the battery snap to screw-terminal block J1, with the red lead to Vs and the black lead to 0 V 5. Connect the 9 V battery to the battery snap	6. Green LED D2 does not illuminate 7. DC motor does not operate
8. Adjust switch S1 to the centre (ON-1) position	9. Green LED D2 illuminates 10. DC motor operates at full speed
11. Adjust switch S1 to the right-most (ON-2) position	12. Green LED D2 illuminates 13. DC motor does not operate
14. Adjust switch S1 to OFF 15. Move the link-cable from test-pin Vs1 (DC output #1) to test-pin Vs2 (DC output #2), leaving the other end on test-pin M (DC motor)	16. Green LED does not illuminate 17. DC motor does not operate
18. Adjust switch S1 to ON-1	19. Green LED D2 illuminates 20. DC motor does not operate
21. Adjust switch S1 to ON-2	22. Green LED illuminates 23. DC motor operates at full speed

Check the variable output (Var) using the 12V DC motor

Actions	Observations
1. Adjust switch S1 to OFF 2. Move the link-cable from test-pin Vs2 to test-pin Var (variable DC output), leaving the other end on test-pin M 3. Slowly rotate RV1 to the fully-clockwise position, and back to the fully-anticlockwise position	4. Green LED D2 does not illuminate 5. DC motor does not operate
6. Adjust switch S1 to ON-1	7. Green LED D2 illuminates 8. DC motor does not operate
9. Slowly rotate RV1 to the fully-clockwise position, and back to the fully-anticlockwise position	10. DC motor operates, reaching full speed when RV1 is fully clockwise
11. Adjust switch S1 to ON-2 12. Slowly rotate RV1 to the fully-clockwise position, and back to the fully-anticlockwise position	13. DC motor operates, reaching full speed when RV1 is fully clockwise. **The Var output is active in both the ON-1 and ON-2 positions of switch S1**

3.3 Astable Multivibrator section

Power the multivibrator (Vmu) from the DC Supply Control (Vs1)

Actions	Observations
1. Adjust switch S1 to OFF 2. Connect a link-cable from test-pin Vs1 to test-pin Vmu (multivibrator power supply) 3. Rotate trimmer potentiometers RV2 and RV3 to their fully clockwise positions 4. Adjust switch S1 to ON-1	5. Green LED D2 illuminates 6. Yellow LED D3 and red LED D4 alternately flash – once per second (approximately)
7. Slowly rotate RV2 anti-clockwise	8. The ON time of yellow LED D3 decreases
9. Slowly rotate RV3 anti-clockwise	10. The ON time of red LED D4 decreases

Check the switched output (Vsw) using the 12V DC motor

Actions	Observations
1. Adjust switch S1 to OFF 2. Connect a second link-cable from test-pin Vsw (electronically switched output) to test-pin M (DC motor) 3. Rotate trimmer potentiometers RV2 and RV3 to their fully clockwise positions 4. Adjust switch S1 to ON-1	5. Green LED D2 illuminates 6. Yellow LED D3 and red LED D4 alternately flash – once per second (approximately) 7. DC motor operates while red LED D4 illuminates

3.4 Inductor-Capacitor Oscillator

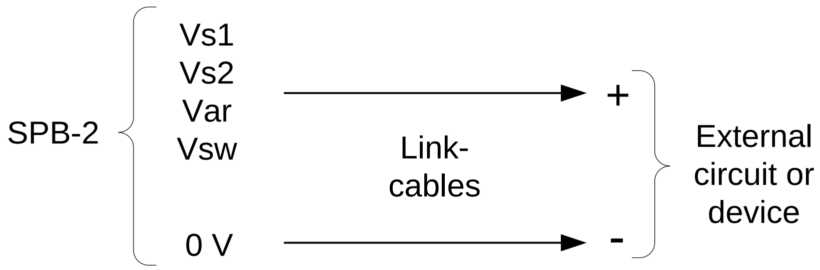
Power the oscillator (Vos) from the DC Supply Control (Vs1), and audibly check the output (Vc) with the piezoelectric transducer

Actions	Observations
1. Adjust switch S1 to OFF 2. Connect a link-cable from test-pin Vs1 to test-pin Vos (oscillator power supply) 3. Connect a second link-cable from test-pin Vc (collector terminal of transistor Q5) to test-pin P (piezoelectric transducer) 4. Adjust switch S1 to ON-1	5. Green LED D2 illuminates 6. Piezoelectric transducer sounds at about 4 kHz, driven by the oscillator
7. Try powering the oscillator from Vsw (electronically switched output from the multivibrator) as was done previously with the DC motor	8. Oscillator drives piezoelectric transducer while red LED D4 illuminates

4 Example applications

4.1 Power external circuits

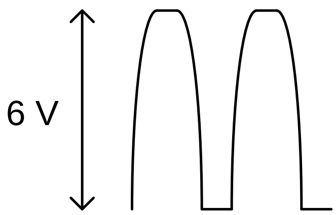
All switched and variable DC outputs from the SPB-2 (Vs1, Vs2, Var and Vsw) are over-current protected by the 300 mA polyfuse F1, so will safely power circuits or devices external to the SPB-2.



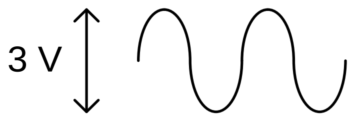
4.2 Explore AC waveforms

The AC waveforms produced by the Inductor-Capacitor Oscillator can be viewed on an oscilloscope. Connect the earth clip of the oscilloscope probe to a 0 V test-pin, and connect the probe tip to test-pin Vc, V_L or Ve. The following 4 kHz waveforms are typical of an SPB-2 powered from a 9.0 V supply:

Vc (clipped sine-wave)



V_L (sine-wave)



Ve (distorted sine-wave)

4.3 Explore transformer action

If the primary winding of a transformer is used for inductor L1 in the Inductor-Capacitor Oscillator, a voltage will be induced across the secondary winding when the circuit oscillates.

The secondary winding is electrically isolated from the primary winding (this can be verified with a multimeter on resistance range) so any voltage observed across it must be the result of magnetic coupling between the windings. If the two windings have the same number of turns, the voltage induced across the secondary winding will be the same as that across the primary winding (V_L) – as shown here:

Secondary winding voltage, measured between terminals 3 and 4 of L1.