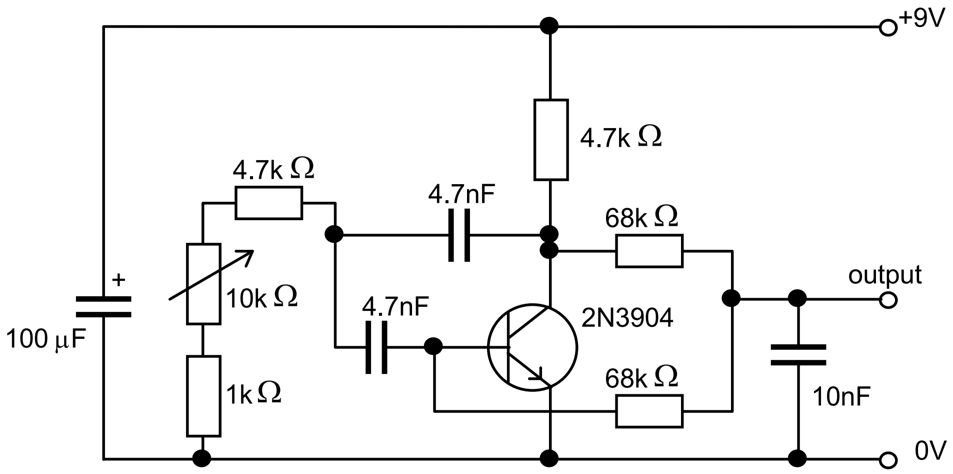
Improved Morse Code Oscillator.

Specification
Sine wave output.
Adjustable frequency ~700 - 2000Hz.
Powered by 9 - 14V.

Background
Many Morse code practice oscillators are based on astable circuits producing a 'square' wave type output. When this is applied to a loudspeaker/sounder, the waveform is distorted to form a spike on the rising and falling edge of the square wave, which can sound unpleasant.
Added to this, the power supply to these circuits is often switched on and off by the morse key with little or no attempt to shape the oscillator output. This usually results in clicks being produced at the start and stop of each dot or dash, which again is unpleasant to hear.
Switching the powersupply can also result in changes in pitch of the oscillator, leading to a 'chirpy' output - again unpleasant to hear.

This morse code oscillator eliminates all of these issues, resulting in a sound that is pleasant and does not become tiring to hear.

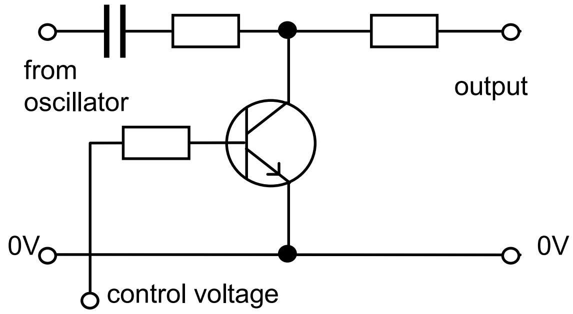
The Circuit
Oscillator
The first part of the circuit is the oscillator.
This is based on the Twin T oscillator circuit and produces a sine wave output with a frequency adjustable from ~700 - 2000Hz.

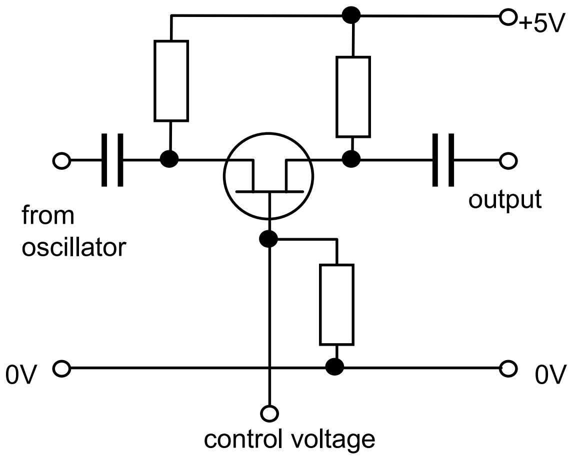


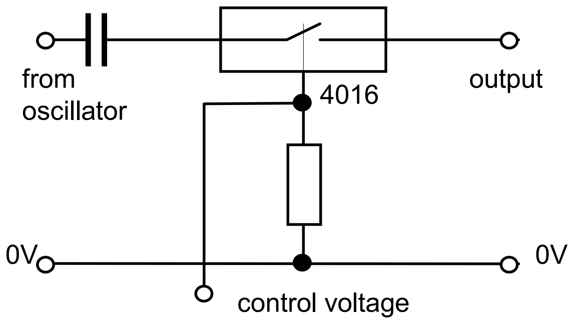
How it works
The transistor functions as an inverting amplifier.
There are two feedback networks connected in parallel from collector to base:-
capacitor-resistor-capacitor and resistor-capacitor-resistor. At one frequency, the effect of these two networks is to produce a phase shift of 180° so that any electrical noise at the collector of the transistor is fed back in phase to the base. This will be amplified and if the gain of the transistor amplifier is just sufficient, will cause the circuit to oscillate producing a sine wave output across the 10nF capacitor. The amplitude of the sine wave output is ~0.5V.
The 10kΩ variable resistor adjusts the frequency of the oscillator.
To eliminate any 'chirp' the oscillator operates continuously.

Voltage Controlled Amplifier (VCA)

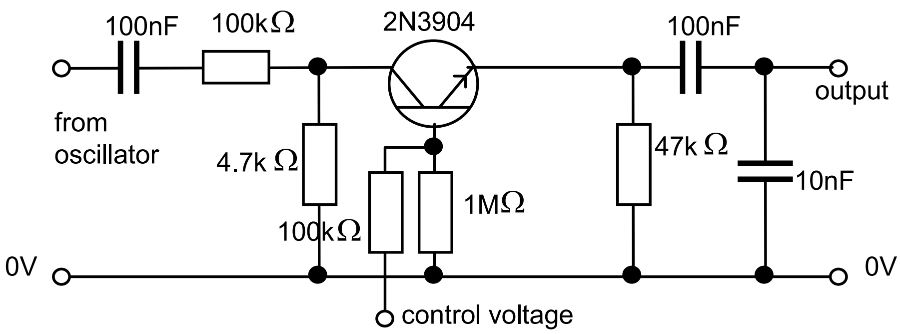
The output from the oscillator needs to be switched on and off by the morse key. To eliminate clicks when the key is pressed and released, the envelope of the output from the oscillator needs to be shaped. This is done using a circuit whose gain can be adjusted by a control voltage.
Several different circuits were tested, including those shown in outline below.







All of these circuits distorted the sine wave as the gain was reduced. Circuits requiring a negative power supply were rejected as were dedicated VCA ICs as these went against the principle of keeping the circuit simple.
A voltage divider formed from a resistor and LDR was also tried. The LDR was sealed in a small container with an LED, a control voltage being applied to the LED. While this had the potential to work well, giving no noticeable distortion, the decay time was too long and the output sounded more like a bell than a morse code dot or dash.
The circuit below gave the best results and was adapted from an old design for a VCA in an analogue music synthesiser.

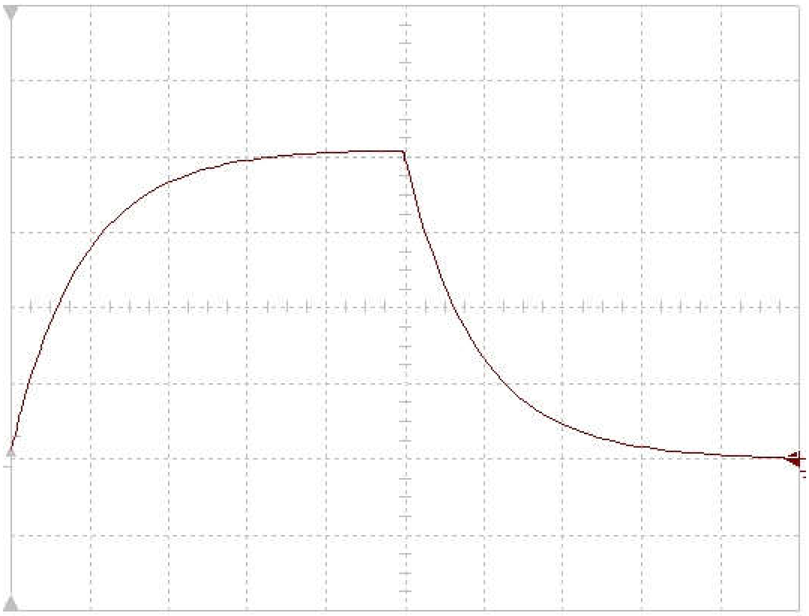


How it works

The input signal is attenuated to ~25mV by the 100kΩ and 4.7kΩ resistors. As the control voltage increases, the base emitter junction of the transistor conducts and the oscillator signal is produced across the 47kΩ resistor. Increasing the control voltage above ~2.5V produces little increase in output signal. The output signal reduces to zero, with little distortion, as the control voltage is reduced to zero.

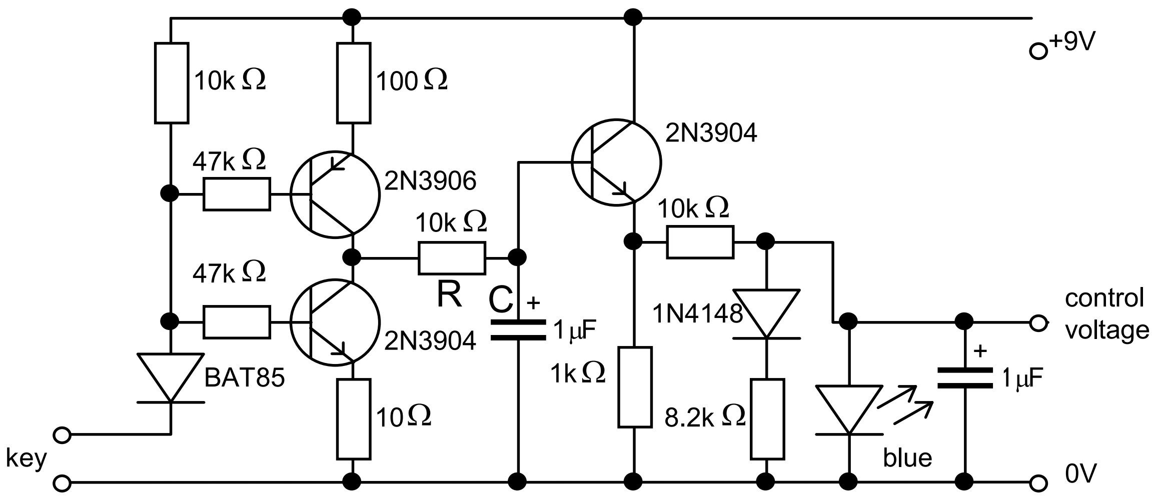
Control Voltage

The diagram below shows the charging/discharging curve for the voltage across a capacitor.



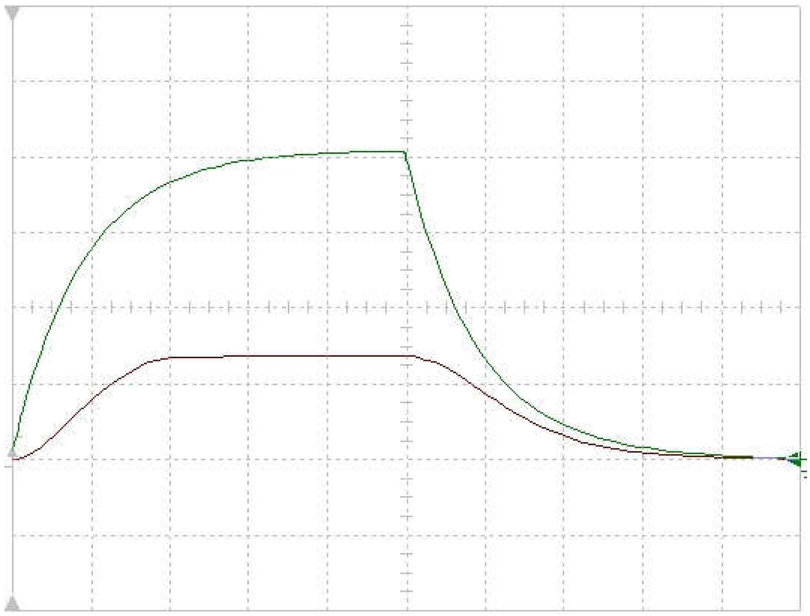
The charging section provides a suitable control voltage to operate the VCA, but the discharge section gives a click due to the very rapid initial discharge and so, in this form, is unsuitable.
This charging/discharging waveform can be modified by using diodes and resistors to limit the maximum voltage. This is the same method that is used in many basic signal generators to produce a 'sine wave' output from a triangular waveform.

The circuit used is shown below.



How it works

The capacitor, C, and resistor, R, form the main charging/discharging circuit.
The charging resistor, R is switched from 0V to +9V by the transistor switch formed from the 2N3906 and 2N3904 pair. The BAT 85 type diode is used to isolate the switch from any other circuits connected to the Morse Key. The BAT 85 is used because its forward voltage is only around 0.3V and so ensures that the 2N3904 transistor of the switch actually switches off. It can be substituted for any other Schottly diode.
The voltage across the capacitor is buffered by the 2N3904 emitter follower. As the voltage across the capacitor begins to rise, the 1N4148 diode and 8.2kΩ resistor start to reduce the increase in voltage. The blue LED, has a turn on voltage of ~3V and so clamps the control voltage output to ~+3V. On discharge, the control voltage does not decrease until the capacitor voltage has decreased significantly, so eliminating the very rapid initial drop in voltage as the capacitor discharges.



The capacitor charge/discharge is shown in green and the control voltage in brown.

Amplifying the output.

The output from the VCA is ~100mV with an impedance of ~47kΩ and so needs to be amplified before connecting to headphones or a loudspeaker.
Any amplifier with an input impedance of more than 47kΩ is suitable.
An LM386 IC would make a good choice.