And now ladies & gentlemen . . . the incredible all-singing, all-dancing

PC Birdies

By RON DE JONG

Is it a magpie, is it a budgie? — no, it's "PC Birdies", the all-singing, all-dancing electronic canaries. But although it may not have quite the same appeal as real canaries, this project will keep a lot of people guessing. It uses just one CMOS IC to electronically generate the pleasant whistling and chirping of two canaries.

Once in a while we let our hair down at "Electronics Australia" and come up with a great little project that performs well but has no earthly use – like this one. We called it "PC Birdies", though some of the other names we came up with were "Hot Canaries", "Chirpy Chip Chip" and "Chip Chicks". Despite the awful puns embodied in these names we still think this project will really "take off".

Using just one "garden variety" CMOS IC, our project generates the realistic sound of two canaries merrily chirping and trilling away. The period of the chirping and the note of each bird is different, creating a random effect with the birds coming in an out of chorus.

If you don't have a canary already, "PC Birdies" can make an interesting addition to say an indoor garden arrangement, or as a talking point at parties or just to amuse the kids. If you do have a canary this little unit will probably give him some company and get him chirping.

An unusual application would be as an alarm for a digital clock. Rather than being woken by the harsh sound of a buzzer you can be woken to the pleasant sound of canaries chirping away. It also makes a great gimmick; take it into a boring lecture, or stuff it in a case and leave it in a public place (we don't recommend that you try this when passing through customs, though!).

THE CIRCUIT

Looking now at the circuit, we can see that it consists of one 74C14 hex Schmitt trigger plus a lot of resistors and capacitors, and a transistor driving an 8Ω loudspeaker. There are two quite distinct circuit sections, one for each canary sound, and each consists of three Schmitt trigger oscillators. The two sections are essentially the same except for slight component changes, so we will only discuss the operation of the section consisting of IC1a,b,c.

The three separate oscillators comprise the canary sound synthesiser: a timing oscillator, a chirp oscillator and a note oscillator. These are all Schmitt RC oscillators so before we go any further we'll look at how a Schmitt trigger functions.

Schmitt triggers have two well defined trigger voltage levels, an upper trigger voltage called Vt+ and a lower trigger voltage called Vt–. If the input voltage to the Schmitt exceeds the upper trigger voltage Vt+ then the output will be low; but if the input voltage is less than the lower trigger voltage Vt– then the Schmitt output will be high. The only other input condition is when the input voltage is between Vt+ and Vt–; in this case the output of the Schmitt merely remains in its previous state, ie either high or low.

This effect is referred to as hysteresis and it enables us to make an extremely simple RC oscillator.

Fig. 1 shows a standard RC Schmitt oscillator plus the voltage waveforms at

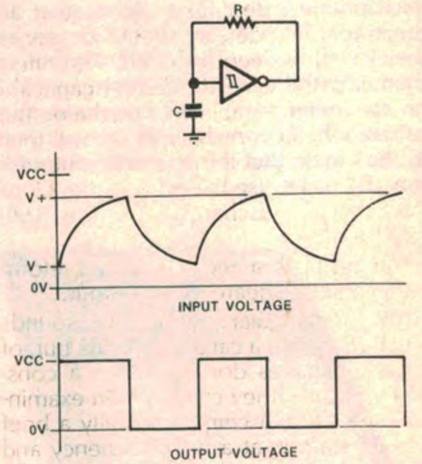


FIG. 1

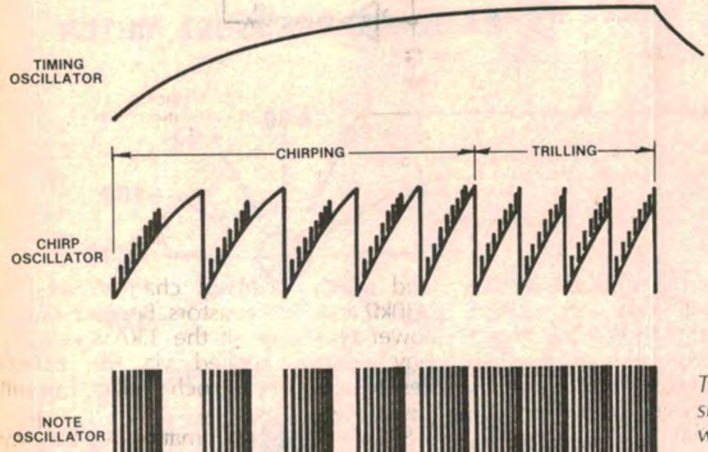


FIG.2

This diagram shows the waveform generated by each of the Schmitt oscillators.

Bird doggerel

A solid-state birdie is one thing
But what can you christen the same?
"Chique chick" or "Cheap cheep" or something,
Or maybe a "Warbling whatname"?

The term "Schmitter twitter" is clever,
"Tricky Dicky" is short and much neater;
"Lorikeet that is Liceless" sounds nasty
But then, what about "Money Eater"?

Call it "PC Birdies" . . .
And stop arguing!

the input and output. Assuming that the input voltage is at Vt–, the output voltage will be high. This causes the capacitor to charge up via the feedback resistor, giving the input voltage waveform shown on the diagram. When the capacitor is charged up to Vt+ the Schmitt output will go low, discharging the capacitor until it reaches Vt–, and the whole cycle is repeated. The period of the oscillator is proportional to the RC time constant.

Referring to the main circuit diagram now, IC1c is the note oscillator and it generates the note of the canary's chirp. Its operation is the same as the Schmitt oscillator just described except that an additional diode and 330kΩ series resistor have been included. The effect of this is to make the 220pF capacitor charge up more rapidly when the output of the Schmitt is high since D3 will then be biased on. But if the Schmitt output is low, D3 is reverse biased and the 220pF capacitor is discharged via the 1MΩ resistor alone.

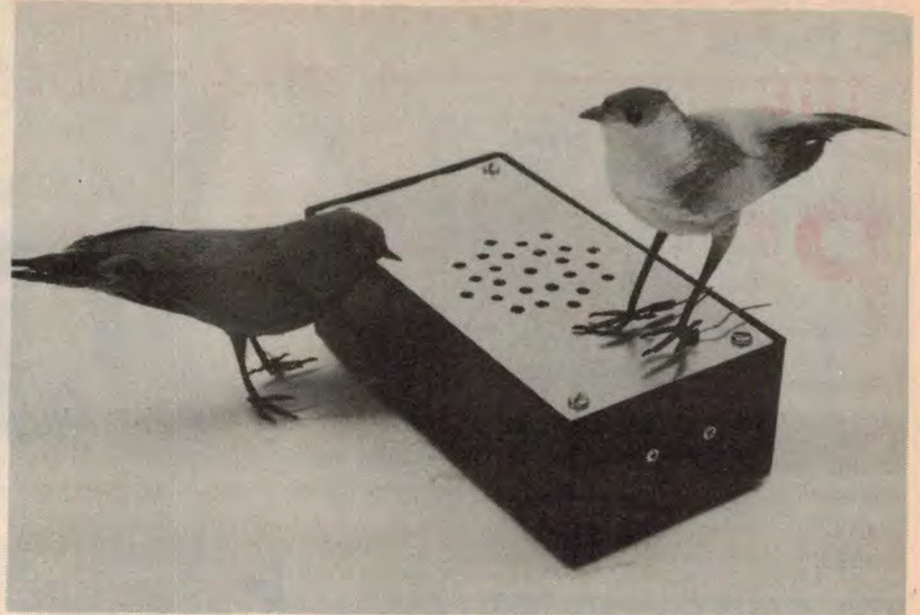
The result is a rectangular waveform rather than a square wave output.

This rectangular waveform sounds much more like a canary's whistle but, of course, canaries don't produce a constant whistle – they chirp. When examined on a CRO, a chirp is actually a brief whistle starting at a high frequency and sliding down to a lower frequency. To synthesise this chirp we have to control the frequency of the note oscillator, and this is done using oscillator IC1b, called appropriately enough a chirp oscillator.

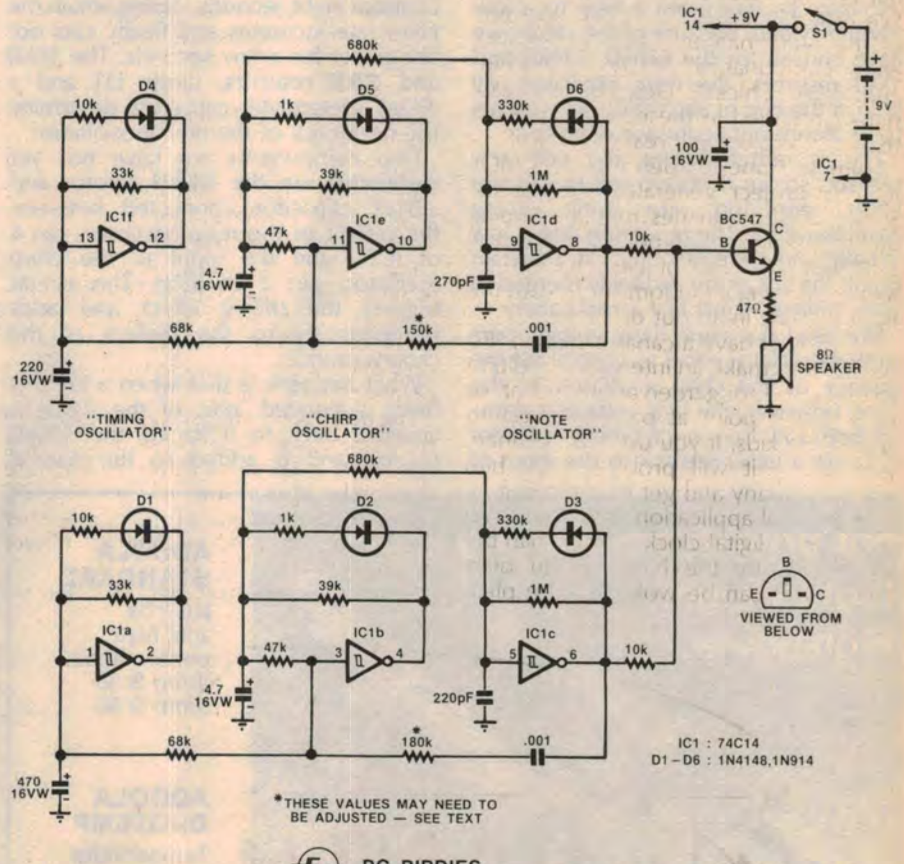
The chirp oscillator generates a sawtooth waveform across the 4.7μF capacitor and this voltage in turn controls the frequency of the note oscillator via a 680kΩ resistor. Leaving the question of how this voltage changes the frequency of the note oscillator for the moment, the chirp oscillator functions in the same way as a standard Schmitt oscillator except that, in this case, a 1kΩ resistor and diode D2 have been added.

When the output of IC1b is high, D2 will be reverse biased and the 4.7μF capacitor will charge up slowly via the 39kΩ resistor. However, when the upper trigger voltage level Vt+ is reached and the Schmitt output goes low, the 4.7μF capacitor will be rapidly discharged via the 1kΩ resistor and D2 which is now forward biased. The waveform across the 4.7μF capacitor is therefore a slowly rising waveform followed by a rapidly falling edge as shown in Fig. 2.

This sawtooth waveform is used to bias IC1c via the 680kΩ resistor and controls the frequency of the note oscillator as follows. Assuming that we are looking at the discharge cycle of IC1c – ie the 220pF capacitor is discharging via the 1MΩ resistor – any voltage applied via the 680kΩ resistor will be added to the low output of IC1c via the 1MΩ resistor. In effect, the 1MΩ and 680kΩ resistors form a voltage divider and the 220pF capacitor will discharge down to this



It may not look like a real canary, but it sure fooled these dummies. The birds are available from Bradford Potter Pty Ltd, 608 Harris St, Ultimo 2007.



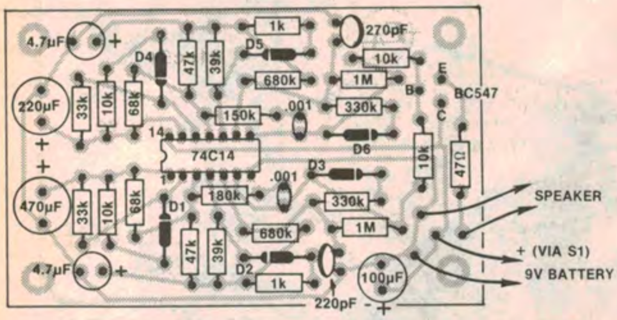
PC BIRDIES

voltage. The closer this voltage is to Vt– the longer it will take the 200pF capacitor to discharge to Vt– and trigger IC1c. In fact if the voltage is greater than Vt– it will never trigger.

In summary, increasing the voltage applied via the 680kΩ resistor will slow down the discharge cycle and if it is sufficiently high it will cut the oscillator off altogether. On the charge cycle – ie with IC1c output high – D3 is forward biased and the capacitor is charged via the 330kΩ and 1MΩ resistors. Because of the lower resistance of the 330kΩ resistor, any voltage applied via the 680kΩ resistor will have a much smaller, but still discernible, effect.

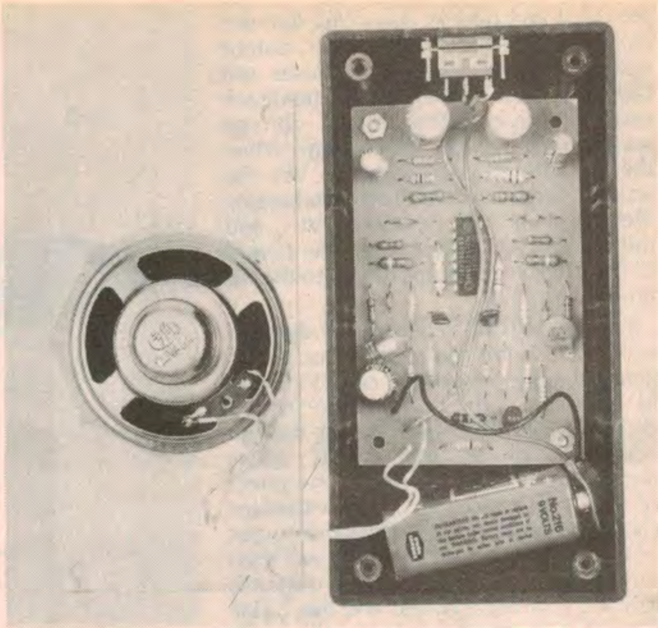
So to a first approximation we can say simply that the frequency of the note oscillator decreases with increasing bias voltage.

The sawtooth waveform from the chirp



Above: The component overlay diagram for the PCB. Make sure that all polarised components are inserted the right way round.

RIGHT: Inside the completed prototype. A piece of foam rubber can be used to hold the battery in place.



oscillator will therefore cause the note oscillator to slide from a high to a low frequency and, because of the values we have chosen for the 680kΩ, 330kΩ and 1MΩ resistors, the note oscillator will stop at the end of each chirp. So we now have a constant sequence of chirps.

This is rather boring and not very realistic, so our next step was to vary the chirp repetition rate using timing oscillator IC1a. The repetition rate is low initially and increases until, at a certain point, the chirps are suddenly merged to give "trilling" – just like a real canary.

We used the same basic voltage controlled oscillator effect to control the frequency of the chirp oscillator. In this case, however, the bias voltage is derived from low frequency timing oscillator IC1a via a 68kΩ resistor to the input of IC1b. The timing oscillator has a period of about eight seconds, during which the chirp rate increases and finally cuts out altogether for a few seconds. The 10kΩ and 33kΩ resistors, diode D1 and a 470µF electrolytic capacitor determine the frequency of the timing oscillator.

Two components we have not yet mentioned are the 180kΩ resistor and .001µF capacitor connected between the output of the note oscillator, pin 6 of IC1c, and the input of the chirp oscillator, pin 3 of IC1b. This circuit triggers the trilling effect and adds tremendously to the realism of the canary sound.

What happens is that when a chirp is being generated, part of the signal is coupled back to IC1b via the 180kΩ resistor and is added to the normal charging waveform of the chirp oscillator. At the start of the timing cycle this "trill" signal has no effect on the chirp oscillator because the signal cuts out before the Vt+ trigger voltage of IC1b is reached.

Due to the biasing effect of the timing oscillator the chirp period gets shorter but the percentage of time for which the note oscillator is enabled increases. So as the chirp period shortens we get to the stage where the superimposed trill signal causes the chirp oscillator, IC1b, to prematurely trigger, and this is the start of the trilling. When this happens, the charging voltage across the 4.7µF capacitor in the chirp oscillator does not go all the way to Vt+ and in fact never gets high enough to cut the note oscillator off. Result – a rapid sequence of chirps merged together.

Operation of the other canary sound circuit is similar but we have changed some component values to give a more interesting sound effect. The reader is also free to experiment with circuit values. To give some idea of what can be done, increasing the 470µF capacitor in the timing oscillator will increase the period over which the chirping is repeated; decreasing the 68kΩ resistor to pin three of IC1b will cause the sound to cut out for a greater time.

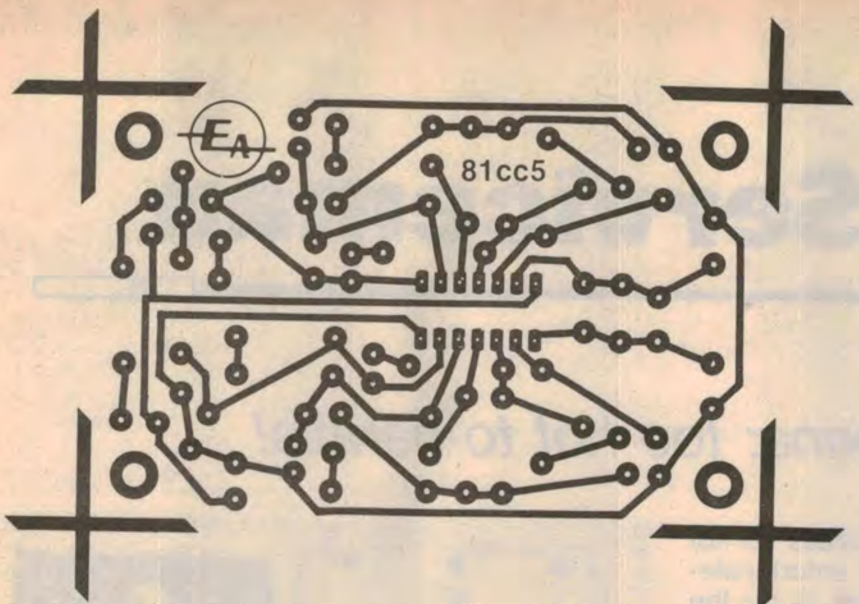
The chirp period can also be reduced by reducing the 4.7µF capacitor, and the pitch of the chirp increased by reducing the 220pF capacitor.

Some slight differences in hysteresis

We estimate the current cost of parts for this project is about

$15

including sales tax



Actual size reproduction of the PCB artwork.

voltages between various 74C14s (the quoted range is 2V to 7.2V at Vcc=10V) will cause variations in the performance of the trilling circuit. So the reader may have to initially experiment with a suitable value for the 180kΩ and 150kΩ resistors in each circuit. If the resistor value is increased, trilling will occur later or perhaps not at all, whereas if it is decreased trilling will occur sooner and last for a longer time. To simplify this procedure we suggest that you only have one circuit connected to the speaker at a time.

Outputs from both circuits are mixed via two 10kΩ resistors and applied to an emitter-follower circuit consisting of a BC547 transistor. The speaker forms the emitter load and the 47Ω resistor limits the sound output to a tolerable level. If desired, the 47Ω resistor can be reduced to increase the volume, although this will also increase the current consumption.

The whole circuit is powered from a single 9V transistor battery and current consumption is about 10mA. The circuit works just as well at lower supply voltages, though the resistors in the trill circuit may have to be adjusted.

CONSTRUCTION

Construction of the unit is straightforward. All components with the exception of the speaker, battery and on/off switch are mounted on a printed circuit board (PCB) measuring 89x56mm and coded 81cc5.

Commence construction by mounting the various components on the PCB according to the component overlay diagram. Fit the resistors and capacitors first, followed by the diodes and the transistor. Make sure that all polarised components are correctly oriented and that the resistors values are correct.

The 74C14 IC is a CMOS device and should be left till last. Take the usual precautions to protect against damage from static electricity; connect the soldering iron barrel to the earth track of the PCB using a clip lead, and solder the supply pins (7 and 14) first.

We mounted the assembled PCB inside a small plastic zippy box measuring 130x68x41mm. You will need to drill holes in the case to mount the board and to accept the on/off switch, as shown in the photographs. Additional holes are drilled in the aluminium lid to provide a grille for the loudspeaker, which is glued in position using epoxy adhesive.

With construction completed, you are now ready to unleash the unit on your friends and an unsuspecting public. Have fun!

PARTS LIST

1 zippy box, 130x68x41mm
1 PC board, code 81cc5, 89 x 56mm
1 57mm 8Ω loudspeaker
1 miniature SPDT switch
1 9V battery, Eveready 216 etc
1 battery clip to suit
1 74C14 CMOS hex Schmitt trigger
1 BC547 NPN transistor
6 1N4148 diodes
1 470µF 16VW PC electrolytic capacitor
1 220µF 16VW PC electrolytic capacitor
1 100µF 16VW PC electrolytic capacitor
2 4.7µF 16VW PC electrolytic capacitors
2 .001µF greencap capacitors
1 270pF ceramic capacitor
1 220pF ceramic capacitor

RESISTORS (all ¼W, five per cent): 2x1MΩ, 2x680kΩ, 2x330kΩ, 1x180kΩ, 1x150kΩ, 2x68kΩ, 2x47kΩ, 2x39kΩ, 2x33kΩ, 4x10kΩ, 2x1kΩ, 1x47Ω.