tone-burst generator

A (repetitive) tone-burst signal is an extremely useful aid for testing audio equipment. Basically, this type of test signal is obtained by switching the output of a sine-wave oscillator on and off at regular intervals. The generator described in this article utilises a novel design approach that simplifies the circuit considerably and only involves one minor reduction of the capabilities.

The sinewave is the most commonly used test signal. It is simple to analyse (both 'on sight' and mathematically) so that any distortion can usually be recognised quickly. Its very simplicity, however, is also its main disadvantage: it has very little in common with the signals that an audio system is normally expected to handle: music and speech.

Audio signals are extremely 'dynamic': transients and other more-or-less rapid changes in level are actually the most important information in a speech signal. In order to test a system which is intended to handle this type of material, it seems reasonable to look for a 'dynamic' test signal. There is no way to measure 'transient response' with a signal that is as obstinately steady-state as DC. And that, regrettably, applies to sinewaves.

What about squarewaves? A good second in the list of commonly used test signals. It is definitely better than the sinewave when it comes to pointing out poor transient response. However, it is definitely inferior on several other counts. Just think: a digital NAND gate will pass a squarewave beautifully — but a NAND gate makes a very poor audio amplifier indeed . . .

A tone-burst signal can be considered as a combination of sinewave plus squarewave. It has the advantages of both: it is steady-state for a while, then suddenly changes to a new 'steady state' and so on. A typical tone-burst signal is shown
in figure 1. It consists of one or mo
sinewaves, then a gap (one or more sir
waves in length), then again one or mo
sinewaves and so on. That it is in sor
ways similar to a sinewave is obviou
the similarity with a squarewave
perhaps less apparent, until one realis
that it is basically equivalent to t
output from a sinewave generator that
being turned on and off by a squar
wave generator of lower frequency.

All very well, but how does one obtain
'tone-burst' signal? Apparently, a squar
wave generator must 'gate' the outp
from a sinewave generator. One way
achieving this is shown in figure 2. T
sinewave is fed to an electronic switc
As the switch is opened and closed,
succession of sinewave 'bursts' w
appear at the output. Control of t
switch is rather complicated (more th
this simplified block diagram suggests
The sinewave is fed to a zero-crossi
detector; the output from the latter
used as 'clock' signal for two pr
grammable counters. Only one of the
counters is 'active' at any giv
moment — the other is held in the 'res
position by a flip-flop. When the sel
ted maximum count of the 'acti
counter is reached, the flip-flop is tr
gered. The first counter is then reset a
the other counter is enabled. Since t
output of the flip-flop also drives t
electronic switch, the final result is
number of sinewave periods determin
by one counter, followed by a 'de

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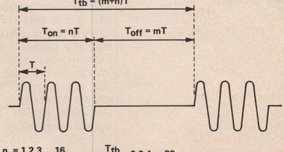

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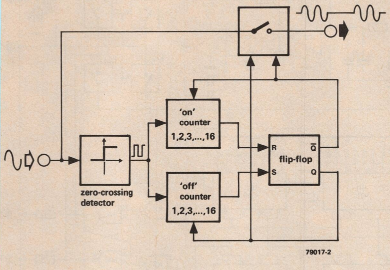

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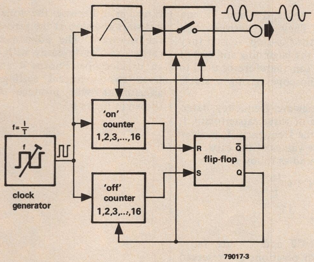

Figure 1. A tone-burst is basically equivalent to a sinewave that is switched on and off at regular intervals. Both the length of the burst and the period between bursts are a whole multiple of the sinewave period.

Figure 2. Block diagram of a conventional tone-burst generator.

Figure 3. Block diagram of a novel alternative.

one' (no output) determined by the econd counter.

fool-proof system, one would think. owever, there is at least one weak link the chain: the zero-crossing detector. f the output tone-bursts are to start nd stop in the zero-crossings of the inewave, an accurate zero-crossing etector is required – not to mention ero phase-shift throughout the comlete chain from detector through couners and flip-flop to switch.

hese problems can be solved – witness he proliferation of commercial toneurst generators that work according to his principle. However, why bother? A ifferent approach obviates the whole roblem. The results are certainly good nough for the home constructor – for that matter, they are good enough for professional use. The only problem is that they make for less sweeping advertisements . . .

Why not?

The block diagram of a different approach is shown in figure 3. At first sight, it is very similar to the diagram shown in figure 2. However, there is one major difference: the clock pulses for the counters are not derived from the sinewave. The reverse is true: a selective filter is used to derive the output sinewave from the clock pulses. And it is easier to design – and, more importantly, build – a good selective filter than it is to obtain a good zero-crossing detector.

Any experienced designer who is conversant with the law of cussedness should, by now, be looking for the 'bug'. It's there all right. If the tone-burst is to be turned on and off at the correct moment – during the zero-crossings – the edges of the clock pulses must still correspond with those zero-crossings. Clock pulses and sinewave must be in phase. This implies that the centre frequency of the filter must coincide with the clock frequency, and a fixed centre frequency therefore leads to a fixed clock frequency. Tone-bursts with 'swept' sinewave frequency are no longer possible. So what . . . who needs 'em, anyway?

The circuit

The complete circuit of the tone-burst generator is shown in figure 4. The burst length can be set, by means of S1, at anything between 1 and 16 complete sinewave periods. The interval between bursts is selected in the same way by S2. The clock generator, N1/N2, is a fairly standard circuit. Its output is not particularly 'clean', but suitable processing by the other four inverters in the same package (N3 . . . N6) produces a good squarewave. As illustrated in the block diagram (figure 3), this signal is fed to two counters, one of which (IC1/IC2) determines the length of the burst while the other (IC3/IC4) fixes the interval between bursts. One output of each counter is selected by S1 and S2, respectively, and used to set and reset the flip-flop (N9/N10). The Q and $\overline{Q}$ outputs of the flip-flop are fed back to the counters in such a way that when the count selected by S1 is reached, toggling the flip-flop, the corresponding counter is reset and the other is enabled. In this way, the two counters are used alternately.

The flip-flop outputs are also used to operate the electronic switches S1 . . . S4. When S1 and S2 are closed, the sinewave appears at the output; opening S1 and S2 and closing S3 and S4 blocks the sinewave and passes a DC level, corresponding to the zero level of the sinewave, instead.

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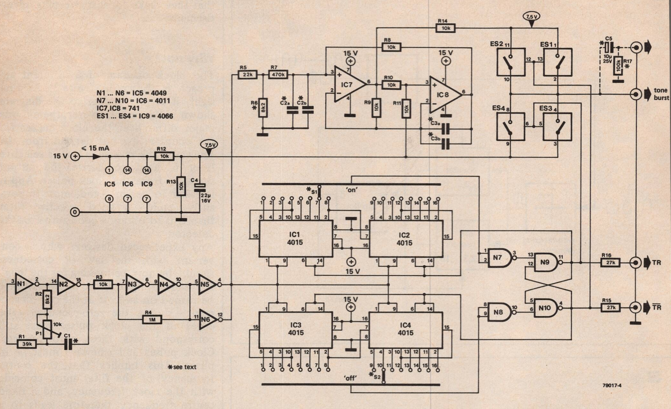

Figure 4. Complete circuit for a tone-burs generator that is more suitable for hom construction.

The sinewave is derived from the clock pulses, as described earlier. The clock pulses are passed through a selective filter (IC7/IC8); the centre frequency of this filter, which corresponds to the clock frequency, is also equal to the sinewave frequency of the tone-burst. If a different tone-burst frequency is required, the clock frequency must be altered by choosing a different value for C1, and the centre frequency of the selective filter must be modified by altering the values of C2a/b and C3a/b.

Construction and calibration

A suitable printed circuit board design is shown in figure 5. Fairly standard components are used throughout, with the possible exception of the switches S1 and S2. Several alternatives are possible at this point, depending on availability and cost: 16 single-pole single-throw switches; a 24-way switch (more common than 16-way); a 12-way switch (four outputs of each counter are left unused); two or more switches in cascade; or even hard-wired internal programming of one useful combination (four periods on, say, and eight periods off).

The amplitude of the sine-wave bursts is approximately 8 V peak-to-peak. A 7.5 V DC component is also present in the output signal - corresponding, of course, to the 'zero' level between bursts. This DC component can be blocked by adding C5 and R17, as shown in dotted lines in the circuit diagram. The amplitude of the output sinewave can be modified by altering the value of R6.

Two 'trigger' outputs, TR and $\overline{TR}$, are also provided. They are derived from the outputs of the flip-flop, so that they change state at the beginning and end of each burst and can therefore be used to trigger an oscilloscope, giving a stable display.

The desired sinewave frequency determines the value of three capacitors: C1, C2 and C3. If the frequency, f, is given in kHz then the values of the capacitors in nF can be found as follows:

$$C2 = C3 = \frac{16}{f};$$

$$C1 = \frac{33}{f}.$$

The values of C2 and C3 are fairly critical, and two positions are reserved on the p.c. board for each of these capacitors so that the desired value can be approximated fairly accurately by connecting two capacitors in parallel. For instance, if an exact 1 kHz sinewave is desired, C2 and C3 would have to be 16 nF; this can be obtained by connecting a 15 n and a 1 n capacitor in parallel. The value of C1 is not so critical, since the frequency of the clock generator can be set correctly by means of P1.

The highest frequency obtainable is 20 kHz.

The current consumption of the circuit is quite low: 12 . . . 15 mA.

The calibration procedure is extremely simple – only one potentiometer (P1) requires attention. The idea is that the clock frequency must coincide exactly with the centre frequency of the active filter, as otherwise the toneburst wi not start and stop at the zero-crossing c the sinewave. The adjustment can b carried out quite easily with the aid c an oscilloscope. Photos 4 and 5 illu trate two incorrect settings; correc adjustment will produce the resul shown in figure 6. ■

Figure 5. Printed circuit board and con ponent layout for the tone-burst generato (EPS 79017).

Photo 1. Tone burst, 1 sinewave period with 16-period gap.

Photo 2. Tone burst, 16 sinewave perioc with a 1-period gap.

Photo 3. Tone burst, 16 sinewave perioc with a 16-period gap.

Photos 4 and 5. Clock signal and tone-bur with P1 incorrectly adjusted: the burst do not start and stop in the zero-crossings of th sinewave.

Photo 6. Tone-burst output after P1 has bee accurately adjusted.

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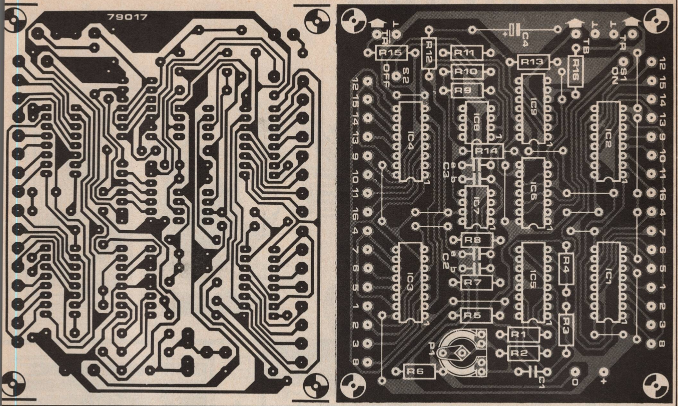

Parts list

Resistors:
R1 = 39 k
R2,R6* = 8k2
R3,R8 . . . R14 = 10 k
R4 = 1 M
R5 = 22 k
R7 = 470 k
R15,R16 = 27 k
R17* = 100 k
P1 = 10 k preset

Capacitors:
C1* = 33 n
C2a/b*, C3a/b* = 15 n + 1 n
C4 = 22 µ/16 V
C5* = 10 µ/25 V

Miscellaneous:
S1,S2 = single pole, 16-way switch*

Semiconductors:
IC1 . . . IC4 = CD 4015
IC5 = CD 4049
IC6 = CD 4011
IC7,IC8 = 741
IC9 = CD 4066

* see text

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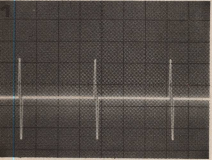

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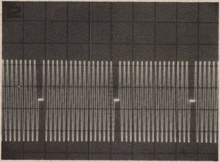

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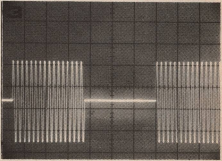

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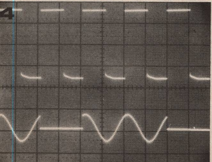

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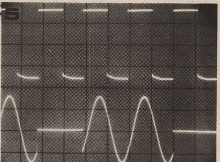

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