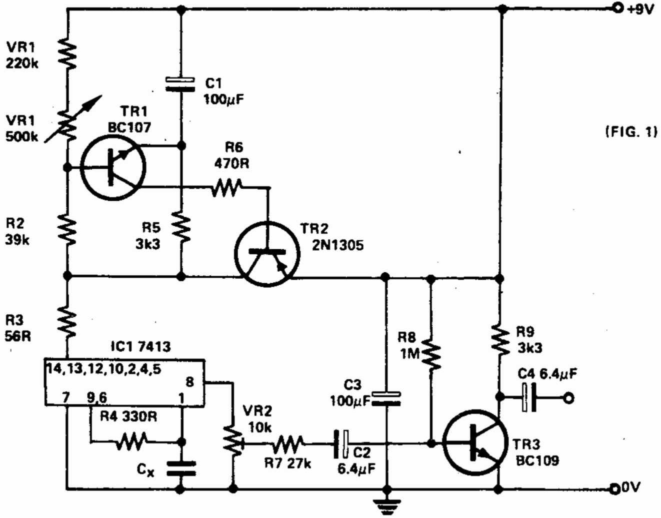
TONE BURST GENERATOR

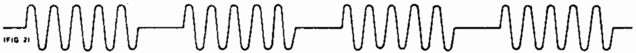
The circuit in Fig. 1 generates the waveform shown in Fig. 2. The output is basically oscillations at a certain frequency outputed in small pulses. This type of waveform has varied uses ranging from a beat for an organ or synthesizer to audio or radio frequency testing.

The variable parameters of the waveform are shown in Fig. 3:-

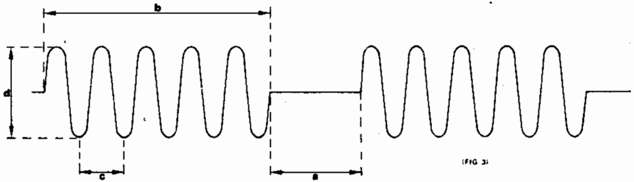
VR1 alters the time between pulses.
C1 alters the length of the pulse.
VR2 alters the amplitude of the waveform.
Cx alters the frequency of the waveform within a pulse. This ranges from .0005 giving RF, to 5 giving AF. (microfarads)



(FIG. 1)



(FIG 2)



(FIG 3)

Generating tone bursts with only two IC timers

by L. W. Herring
LWH Associates, Dallas, Texas

With very few external components, two IC timers can be made to function as a tone-burst generator that is useful for radio and telephone applications. In the circuit shown here, one timer controls the tone burst, and the other generates its frequency.

Normally, a tone-burst generator is built with three timers, two being required for the control function. Although a single timer in its delay mode could provide the initial time period, the second timer is required to generate the burst length and reset the first timer. Alternatively, in the astable mode, a single timer's output duty cycle could be adjusted for the quiet and burst periods, except for one thing—the time to the first burst would be almost twice as long as the time to subsequent bursts because the initial charging period of the timing capacitor is longer than later periods.

Nevertheless, a single timer can in a sense be fooled into providing the control function on its own if an RC network (resistor R_2 and capacitor C_2 in the figure) is added to the timer's (TIMER_1) threshold and trigger inputs. Of course, the larger primary timing network (resistor R_1 and capacitor C_1 in the figure) remains connected to the timer's discharge circuit.

TIMER_1 is set up as an astable oscillator. But its threshold inputs are kept high by the additional RC network (R_2 and C_2) for longer than it takes the timer's discharge circuit to completely discharge the main RC network (R_1 and C_1). This assures that the output period of TIMER_1 remains almost constant, no matter if the burst is the first one or the last one.

The period that TIMER_1's output remains high can be approximated by the standard equation for delay-mode operation:

$$T_{on} = 1.1R_1(C_1 + C_2)$$

The burst output time (when the output is low) can be adjusted to the desired value by the R_2C_2 network. This period is approximated by the equation for astable-mode operation:

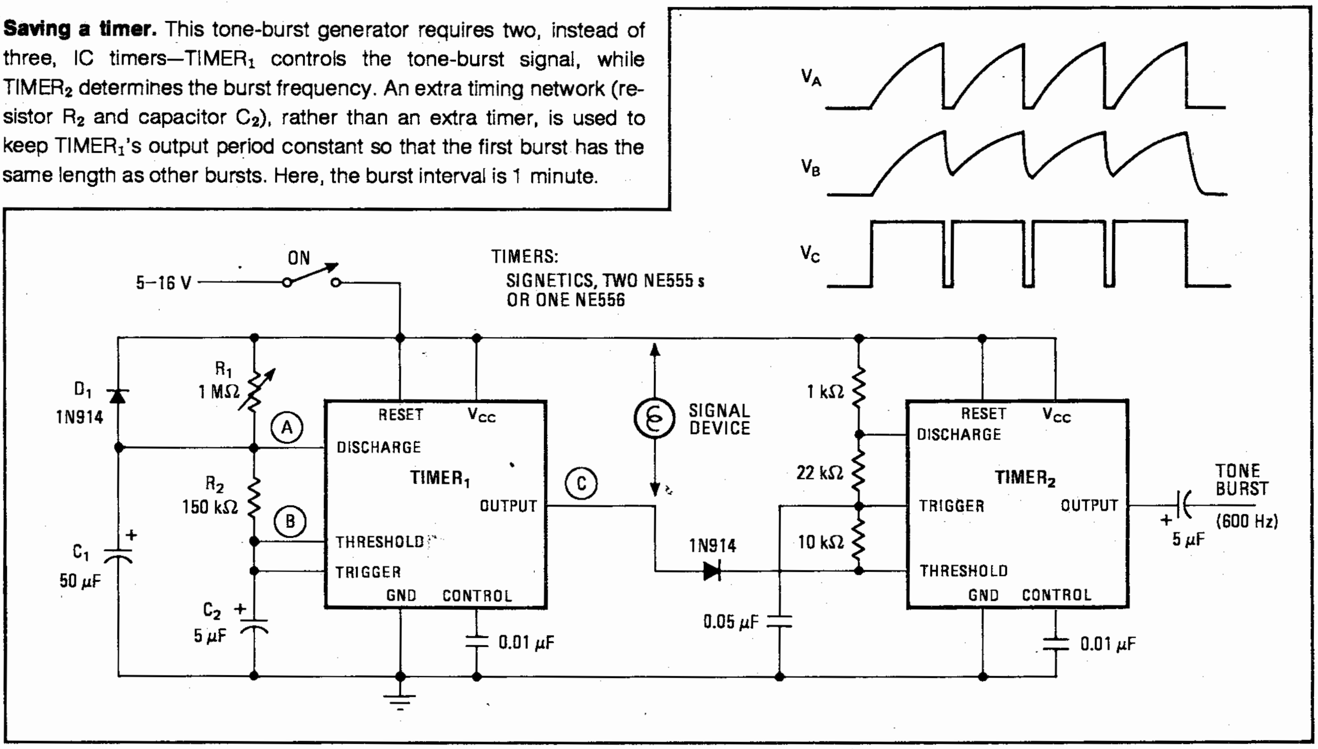
$$T_{off} = 0.693R_2C_2$$

When the added time period (burst length) approaches or exceeds the main time period, the two timing networks interact.

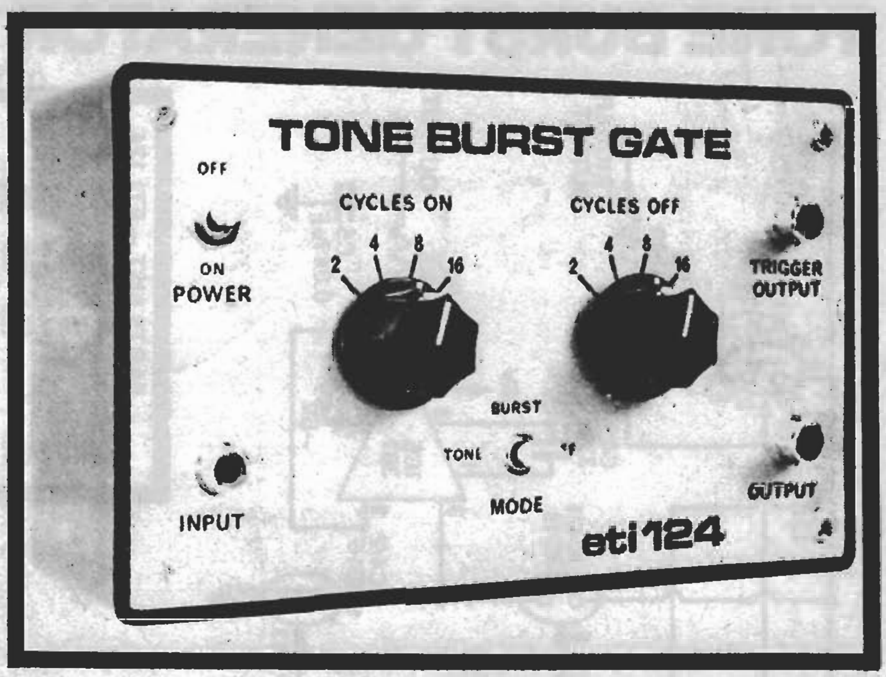
For this circuit, the output of TIMER_1 remains high for 1 minute and goes low for a half second. The best way to activate the circuit is to switch the V_{CC} supply lead for the entire circuit. Diode D_1 assures that capacitor C_1 will be discharged after any partial periods.

The control timer (TIMER_1) can provide the output for a lamp, bell, buzzer, or other signaling device. (This timer's output must be used to sink the signaling device, which must also be wired to the supply line.) TIMER_2 operates as the tone oscillator, determining the frequency of the tone burst. The manner in which TIMER_2 is keyed eliminates the need for an intermediate device to invert the output of TIMER_1 to operate the reset lead of TIMER_2.

This simple tone-burst generator can be used as an audible timing reminder for long-distance telephone calls or for radio repeaters that have 3-minute shutdown timers. The same arrangement can be used to generate sampling pulses for a sample-and-hold circuit or for a serial-to-parallel data converter for Ascii-character detectors. ☐



Saving a timer. This tone-burst generator requires two, instead of three, IC timers—TIMER_1 controls the tone-burst signal, while TIMER_2 determines the burst frequency. An extra timing network (resistor R_2 and capacitor C_2), rather than an extra timer, is used to keep TIMER_1's output period constant so that the first burst has the same length as other bursts. Here, the burst interval is 1 minute.



etiproject 124

TONE BURST GENERATOR

A valuable tool for testing loudspeakers.

TONE BURST testing is a technique which is rapidly gaining acceptance in a wide variety of applications. Typical applications are in testing of hydrophones, signal-to-noise in telephone channels, reverberation chamber testing and in the determination of peak distortion in loudspeakers. With loudspeakers, tone burst testing has the further advantage that the speakers may be tested with their maximum peak power level whilst keeping the average sound output level low enough to not annoy the neighbours — a considerable advantage indeed.

Some time ago our audio consultants, Louis Challis and Associates, asked us to build them a tone-burst generator and the resulting instrument has been used by them ever since with much success.

DESIGN FEATURES

A tone burst must always be an integral number of cycles. If the burst is switched on or off part way through a cycle then undesirable transients will be produced that will mask the test results. Thus the burst must start and end exactly at the zero-crossing point of the sine wave in the burst.

In the original unit, designed for Louis Challis, preset times can be independently selected for the on and off periods of the burst with the exception that the burst time is automatically modified to give an integral number of cycles. The preselected on/off ratio, however, is independant of the burst frequency. To give the required control range, six switched ranges as well as a variable control are provided for both the on and off periods. Other features of the original unit are the ability to start at any point in the cycle as well as the zero crossing point, a phase-inverting switch to select either the positive or the negative half cycle first and an OFF LEVEL control to set a base tone level which is modified when the tone burst occurs. In addition the dc level of the output can be set and a switch is provided to select burst, pure tone or off as required.

When it came to redesigning the unit as a project we decided that many of the features offered by the original design were unnecessary for the user concerned only with testing speakers. Hence the unit has been redesigned in a greatly simplified form.

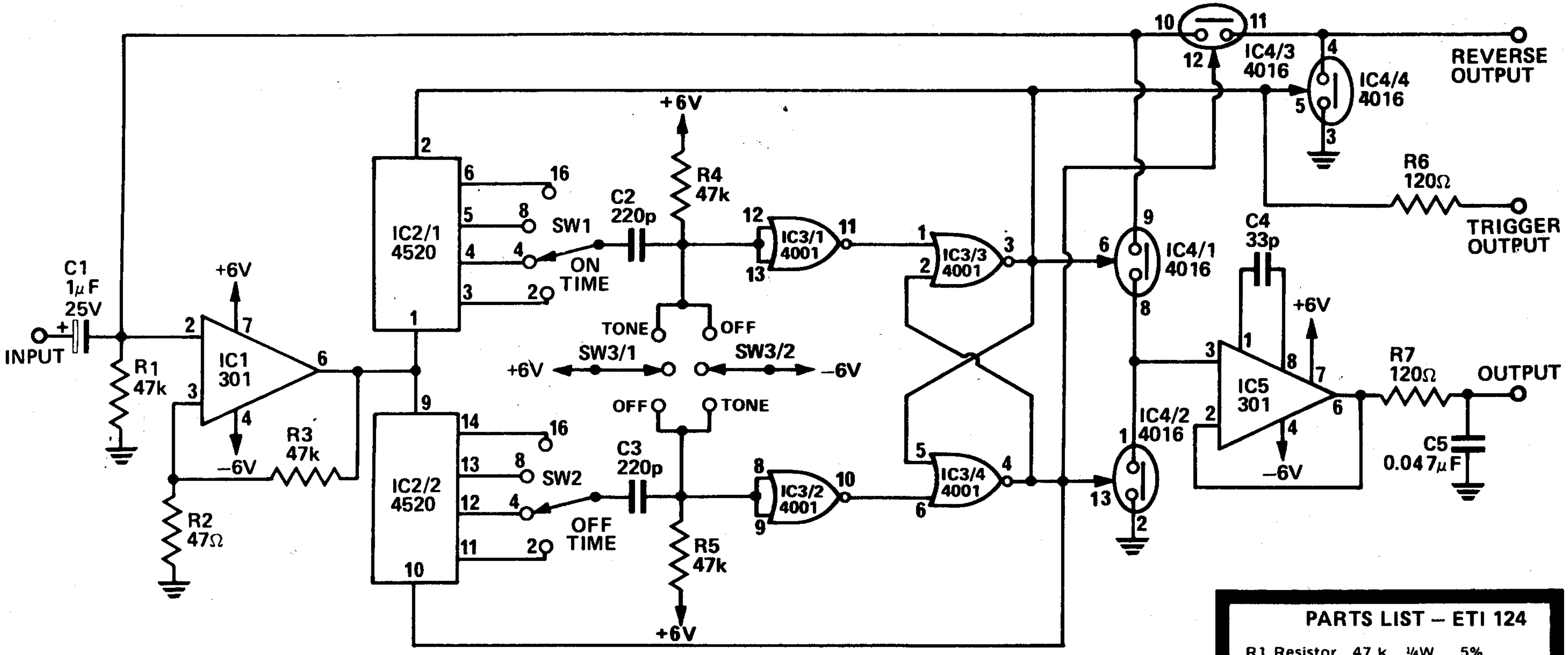
Instead of using monostables to generate variable on/off times we now divide the input with a counter to obtain times that remain in the same ratio regardless of input frequency. We settled for the ability to select 2, 4, 8 and 16 cycles for the duration of either period, as this compromise

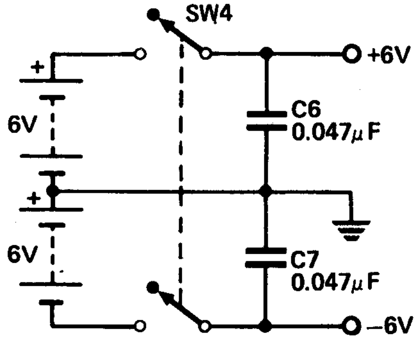
MEASURED PERFORMANCE

TONE BURST GENERATOR.

On Time Cycles.	2,4,8 or 16
Off Time Cycles	2,4,8 or 16
Frequency Response 3 Hz – 300 kHz	+0 –3 dB
Distortion 3 V input at 1 kHz	<0.02%
Input Level Maximum Nominal range	 3 V RMS 100 mV to 1 V
Input Impedance	47 k
Output Noise Voltage with no input	<25 μV
Power Supply Current	4 mA

TONE BURST GENERATOR





POWER RAILS OF IC2, IC3, AND IC4 NOT SHOWN
PIN 16 OF IC2 IS +6V
PIN 8 OF IC2 IS −6V
PIN 14 OF IC3 AND 4 IS +6V
PIN 7 OF IC3 AND 4 IS −6V
PIN 7 AND 15 OF IC2 ARE RESET PINS AND −6V

Fig. 1. Circuit diagram.

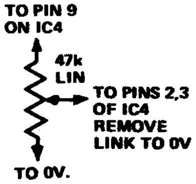


Fig. 4. How to add a potentiometer to the generator for burst-on-tone operation. That is the generator gives a continuous tone level with tone bursts of higher amplitude at intervals.

WHERE TO GET THE COMPONENTS

No problems should be experienced in obtaining the components assuming that you try a CMOS stockist for IC2,3,4. The 4520 is not widely advertised but is available from Sintel under the coding MC1452OCP. The PCB will be available from either Ramar or Crofton.

PARTS LIST — ETI 124

R1	Resistor	47 k	¼W	5%
R2	"	47 Ω	¼W	5%
R3	"	47 k	¼W	5%
R4	"	47 k	¼W	5%
R5	"	47 k	¼W	5%
R6	"	120	¼W	5%
R7	"	120	¼W	5%
C1	Capacitor	1 μF 25V electrolytic		
C2	"	220 pF ceramic		
C3	"	220 pF ceramic		
C4	"	33 pF ceramic		
C5	"	0.047 μF polyester		
C6	"	0.047 μF polyester		
C7	"	0.047 μF polyester		
IC1	Integrated Circuit	LM 301A		
IC2	" "	4520 (CMOS)		
IC3	" "	4001 (CMOS)		
IC4	" "	4016 (CMOS)		
IC5	" "	LM301A		

SW1 Switch 1 pole 4 position rotary
SW2 Switch 1 pole 4 position rotary
SW3 Switch DPDT Toggle with centre off
SW4 Switch DPDT Toggle

PC Board ETI 124
8 1.5V 'AA' pencell batteries
2 4-way battery holders and clips
Plastic case
Escutcheon
3 single phono sockets
2 knobs

HOW IT WORKS – ETI 124

The input signal is squared by comparator IC1 such that the output of the comparator will be high if the input is above +6 mV, and low if the input signal is below −6 mV. Resistors R2 and R3 provide the necessary positive feedback to cause the IC to act as a comparator. The output of the comparator is connected to both clock lines of IC2. If the enable line is high these counters (IC2) will toggle at the input frequency.

IC3/3 and IC3/4 form an RS flip flop where the output must be in either a high or a low state, that is the flip flop has only two stable states. If the output of IC3/3 is high IC2/1 is allowed to clock and, after the number of input pulses selected by SW1 have been counted, the output from SW1 goes low. This low is coupled to the flip flop by C2 toggling the flip flop, disabling IC2/1 and enabling IC3/2. After the number of cycles, as selected by SW2, have been counted the flip flop is again toggled. IC3/1 and IC3/2 are used to square up the pulses generated by C2 and C3 respectively.

The input signal is also coupled to the output buffer, IC5, by the analogue switch IC4/1. When this switch is closed (control signal high) the output of the buffer will be the same as the input. When switch IC4/1 is open IC4/2 will be closed and the output will be held at zero. Since these switches are controlled by the flip flop the output will be the required tone burst.

A trigger output is taken from the flip flop to synchronize an oscilloscope if required. A second output is also available from pins 4/11 of IC4 which is the reverse of the main output.

Switch SW3 forces the flip flop into either of its two possible states thus allowing continuous tone or no output to be selected as required. In the centre position the normal tone burst is obtained.

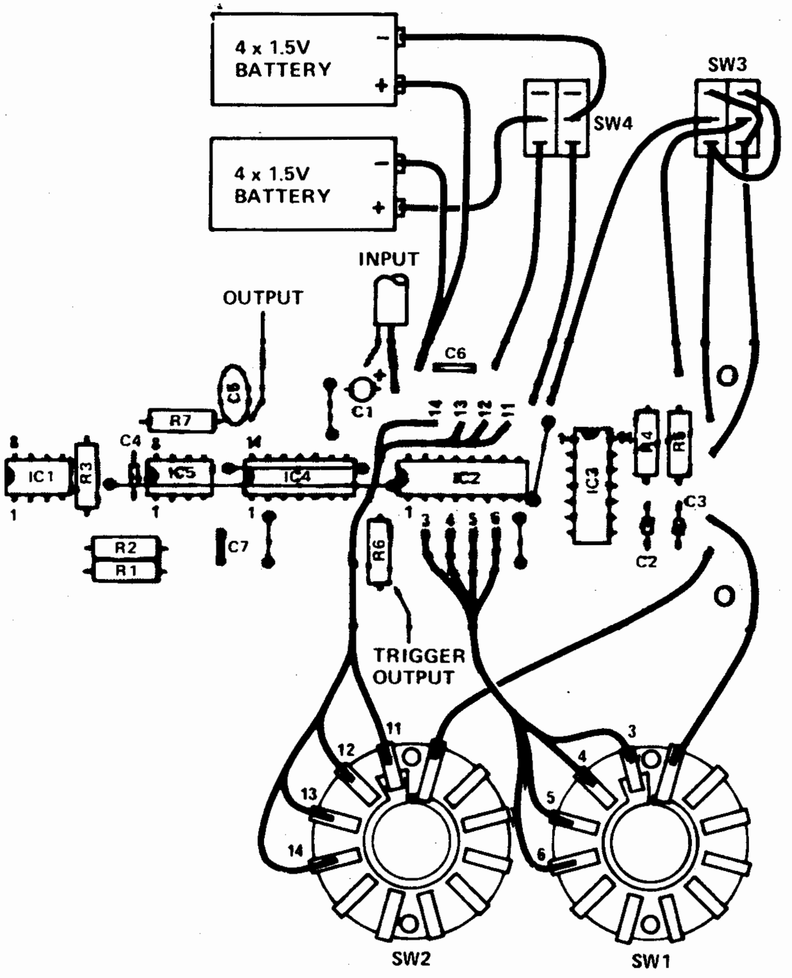
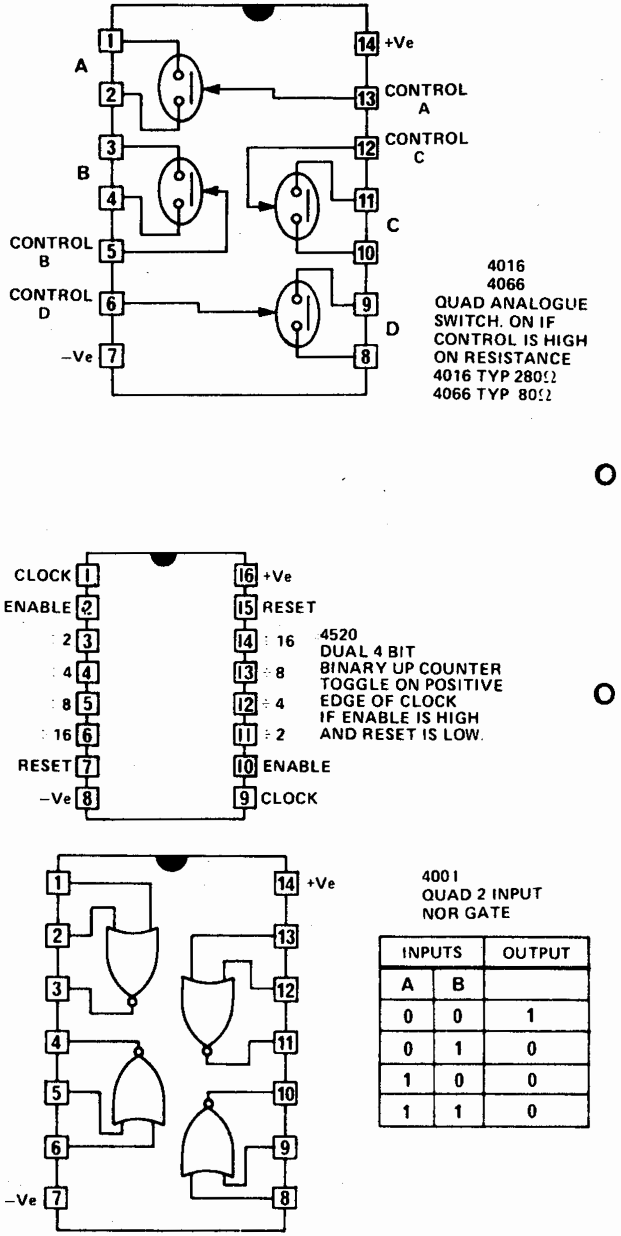


Fig. 2. Component overlay and interconnection diagram. Note that there are six links on the board, including two under IC4, which should be installed first.



INPUTS		OUTPUT
A	B	
0	0	1
0	1	0
1	0	0
1	1	0

Fig. 3. Pin connections of the ICs used in the generator.

TONE BURST GENERATOR

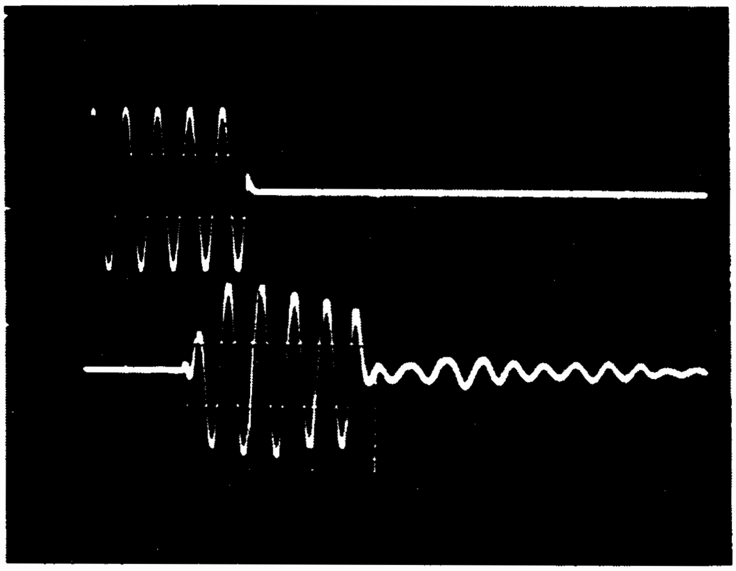


Fig.5 (a) Top trace — the input tone burst of five cycles. (original design).
(b) Bottom trace — the response of a low-cost speaker at 1 kHz. Note the reduced amplitude of the first half cycle and that ringing has added another cycle at the end of the burst. The room reflection can be seen on the trace after the burst.

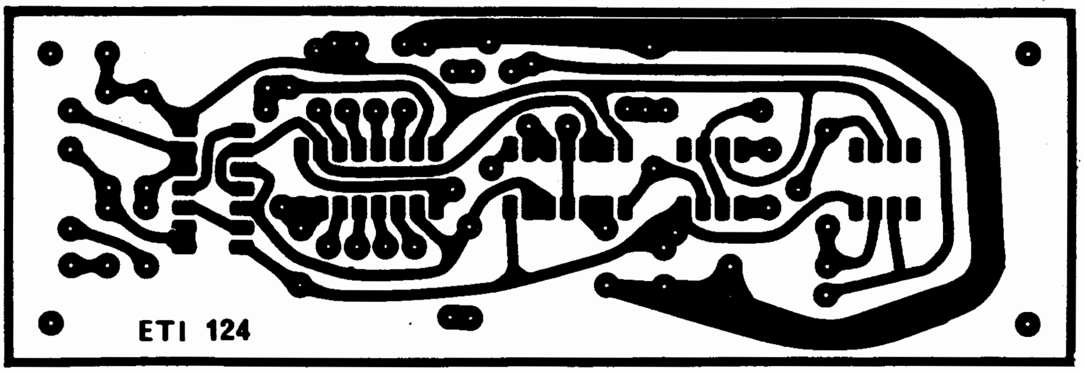


Fig.6. Printed circuit board for the Tone Burst Generator Full size. 142 x 47mm.

greatly simplifies the circuitry. We still have the switch to select tone, tone burst or off, but the OFF LEVEL control has been deleted. The latter control may quite easily be added, however, as shown in Fig. 4. . The output dc level control and the starting-point phase change have also been deleted.

Since we only need half of a CMOS 4016 IC, to give the required output, the other half may be used to give an inverse output if required, that is, the reverse output is on when the other is off and vice versa. This output is not buffered or brought out to the front panel. If it is intended to load this output with less than 47 k it is recommended that a 4066 IC be used instead which will handle loads down to 10 k. For loads of lower impedance than this, a buffer such as is on the normal output should be used.

CONSTRUCTION

As with any project construction is greatly simplified if a printed circuit board is used. However the layout of the unit is not critical and any other suitable method, such as Veroboard or Matrix board may be used if desired. We strongly recommend that sockets be used for the CMOS ICs, especially if a printed circuit board is not used, as these devices are quite easily damaged when soldering. The use of IC sockets also facilitates later servicing. Also remember that, unlike TTL, all unused inputs of CMOS must be connected to either the positive or negative supply rail.

The plastic box that we used measured 160 x 95 x 50 mm and is very convenient in that the printed circuit may be held in position by sliding it down behind two of the pillars to which the front panel is screwed. As the amount of lettering required is quite small, this may readily be done directly on the panel by hand or with Letraset.

Shielding of the internal wiring is not required providing that the unit is kept away from strong 50 Hz fields. If operation in the vicinity of strong fields cannot be avoided then the unit should be mounted in a diecast box.

USING THE UNIT

The testing of loudspeakers is very difficult indeed and much effort is still being spent to find test methods which will not only give an accurate understanding of the relative effectiveness of the design, but which will be easy to reproduce.

One of the main problems with speaker testing is that the speaker cannot easily be isolated from its environment. For example, reflections from the walls of a room modify the response, seen by a microphone, no matter where the microphone is placed in the room. If one could eliminate reflections then the situation would be improved considerably, and hence the use of anechoic (echo free) chambers for testing speakers. But such chambers are very expensive to build and consequently not readily accessible to the amateur.

A further problem is in assessing the transient power handling capability of the speaker. Speakers will handle far greater peak transient power than is indicated by their RMS power rating. This is a very important attribute of loudspeakers in handling musical transients. Any attempt to assess this with a sinewave signal may result in the destruction of the speaker due to thermal failure — apart from also being extremely noisy.

The use of a tone-burst generator minimizes both these problems. How this is achieved is better understood by examination of Fig.5. This shows on the upper trace a five cycle 1000 Hz burst that is fed to a loudspeaker. The second trace shows the same burst as picked up by a microphone in front of the speaker. We notice that the burst has been changed by the speaker and an examination of these changes can tell us a lot about the speaker. For example we notice that the first half cycle has not reached full amplitude and this indicates that the speaker would have some difficulty in reproducing high frequency transients. Next we notice that instead of five cycles there are now at least five and a half. This could mean one of two things. Either there is a speaker/room resonance or, the speaker itself is continuing to vibrate after the original excitation has ceased. Which is it? We can determine this by changing the position of the speaker to see if any change occurs in the shape of the burst, if not it is caused by the speaker itself, and if it does then it is a speaker/room resonance. A speaker that lengthens the burst unduly will sound muddy in that region. Of course the speaker must be examined over its whole range to gain a thorough assessment of performance.

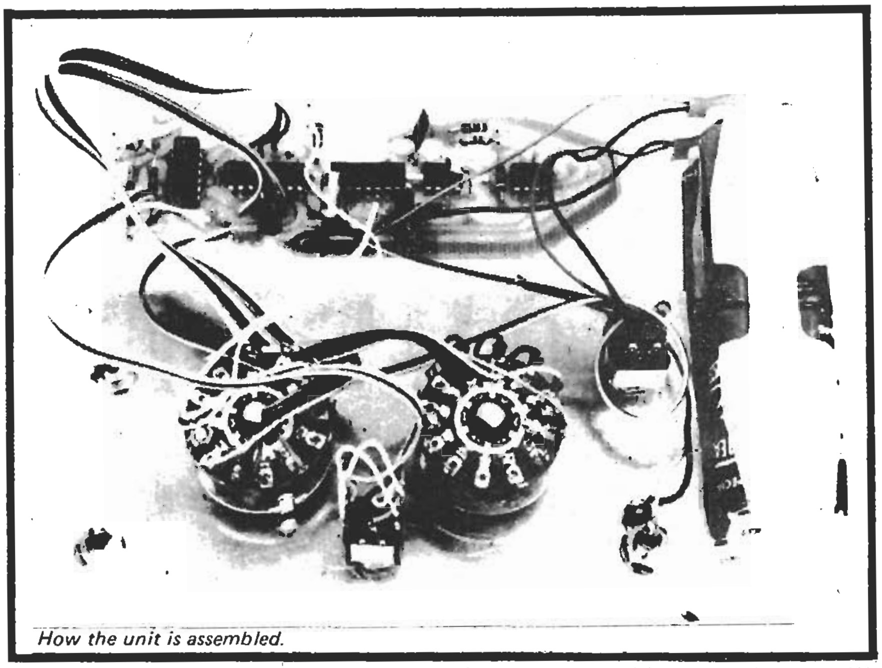
It is of course possible to eliminate room reflections simply by performing the tests outside. However unless one lives in a very quiet area, background noise will introduce problems — and your neighbours are unlikely to appreciate the noise that you will generate.

By varying the off period we can also select a ratio where the room reflection, the oscillation seen after the cessation of the burst, does not interfere with the first few cycles of the burst and the response versus frequency of the speaker may then be assessed from the amplitude of the first half cycles that are stable in amplitude. Thus it is possible to gain an appreciation of the frequency response, transient performance and quality in terms of ringing of a speaker by careful use of the tone-burst technique.

The transient power handling capability of a speaker may be assessed by selecting a fairly long off to on ratio for the burst and by feeding the burst to the speaker via a high-power amplifier. If for example an off to on ratio of 8:1 is used then the peak power will be eight times the average power. Thus the speaker may safely be driven to a peak level where a predetermined amount of distortion occurs. Take care that the amplifier is capable of providing the peak power required.

Of course a tone-burst generator may be used for a wide range of testing. We have mainly concentrated in this article on its application to the testing of loudspeakers.

The circuitry of the tone-burst generator may easily be modified for use as a 'silent switch' for A/B speaker testing. The method of doing this will be described next month. ●



How the unit is assembled.

ETI HELPING HAND COMPETITION

THE PROBLEMS

1 A sick person is being looked after by a deaf person. The deaf person has no useful hearing and requires to know whether the sick person is all right and above all needs to know if the sick person is in a state of distress anywhere in the sick room.

2 A hard of hearing person is attending a College of Further Education and has considerable difficulty in understanding what the lecturer says due to his distance from the lecturer and to the background noise in the room. A device is required to enable him to make the best possible use of his hearing.

3 Many deaf people have great difficulty in using the telephone and in fact many of them cannot use the telephone at all. The development of a writing tablet which would allow them to write a message on a small pad and for this to be communicated over the telephone line to a pad at the other end would have many great advantages. In addition the communication should be two way so that the person can receive a message or an indication that the message has been received.

The Silver Trophy specially designed for the winners of Helping Hand

This is our open competition to find solutions for problems facing the deaf.

This closing date is March 31st 1976. ETI and the Royal National Institute for the Deaf (RNID) are co-operating fully in the organisation of this competition.

Three problems are shown above. We invite individual readers, clubs, schools, universities, companies, in fact anybody, to develop a practical solution. The rules are as basic as possible and impose virtually no restriction apart from insisting that any Patent Royalties are waived if the idea is produced.

The prizes, three in all, will each be a silver trophy specially designed for ETI. At the close of the competition the magazine will hand over £250 to the RNID to help with development costs. There is a £1.00 entry fee (payable to RNID) and this will be added to the £250.

Background information has been prepared to help readers and say what is alreayd known. This is available from ETI on receipt of a large self-addressed envelope. Enquiries should be sent to:

Helping Hand,
ETI Magazine,
36 Ebury Street,
London, SW1W 0LW.

Fast-starting gated oscillator yields clean tone burst

by Walter C. Marshall
National Oceanic and Atmospheric Administration, Seattle, Wash.

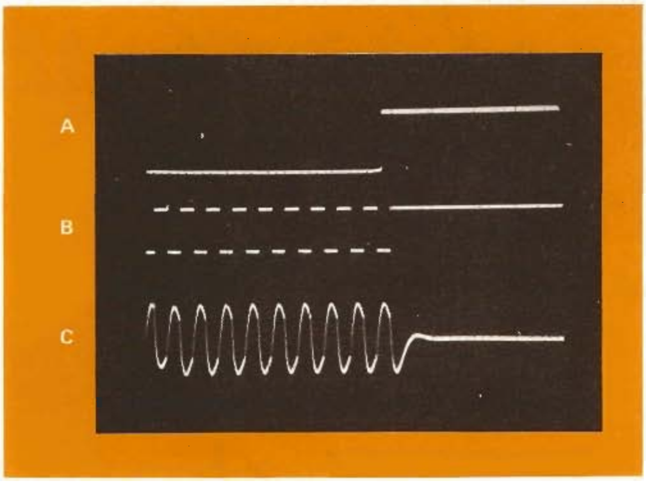
Synchronization pulses required for analyzing recorded data are usually frequency-multiplexed on one channel of a laboratory-type tape recorder. To ensure a high degree of accuracy in the data analysis, the gated tones must exhibit precise start-up and high monotonicity. This gated oscillator, which turns on with the leading edge of the gate pulse, always passes an integral number of cycles. And because the last cycle is never truncated, the oscillator produces no higher-frequency harmonics that could interfere with other decoders.

The complete gated oscillator, shown in Fig. 1, is built with only one complementary-metal-oxide-semiconductor integrated circuit, a 4011 quad two-input NAND gate. Two of the gates, labeled B and C, form the RC square-wave oscillator, which has a frequency that can be adjusted from about 4 to 25 kilohertz by varying the 10-kilohm potentiometer. The remaining two NANDs perform the discrete gating function.

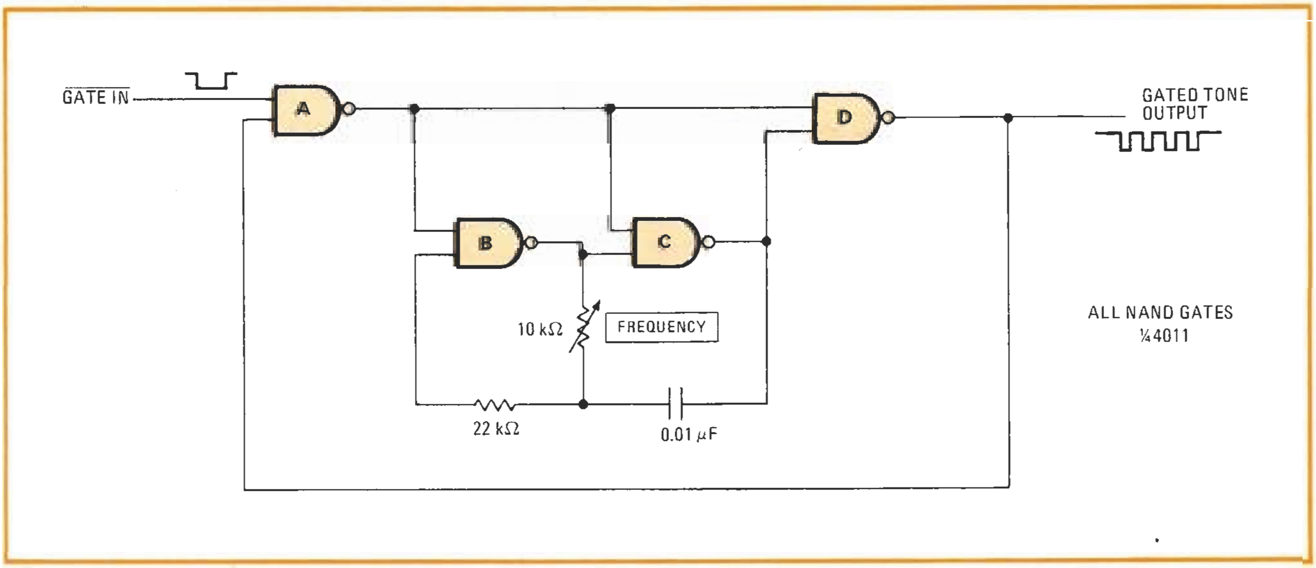
A logic 0 at the input to NAND gate A enables the three other NANDs, and thus the signal at the output of NAND D begins its voltage transition concurrently with the leading edge of the gating pulse. Truncation of the last cycle of the output signal is prevented by returning the signal to input NAND A. If the gating pulse should cease (go high) when the output of D is at a low level, the output of NAND A is unchanged, and the oscillator continues until a cycle is completed. Once the output of NAND D returns high at the end of a cycle, gate A turns off and the tone burst is cleanly terminated.

An oscilloscope photograph of the signals is shown in Fig. 2. Waveform A is the gating pulse, and B is the gated output. At the cessation of the gating pulse (positive transition), the oscillation of the output signal continues until the cycle is completed.

Waveform C is the gated output after it has been passed through a two-pole active bandpass filter to remove higher-frequency components. This tone is then mixed with other synchronization tones and applied to the tape-recorder input. ☐



2. No truncation. Scope photo shows trailing edge of synchronizing signals. Waveform A is the closing of the gating pulse (positive transition), and B shows completion of last cycle in gated tone output, despite closing of gate. Waveform C is the filtered burst, stripped of higher-frequency components for recording.



1. Clean tone burst. One-chip circuit generates tone burst of an integral number of cycles when gated by a negative-going input signal. Basic RC square-wave oscillator built around NAND gates B and C is adapted from RCA applications note ICAN-6267.

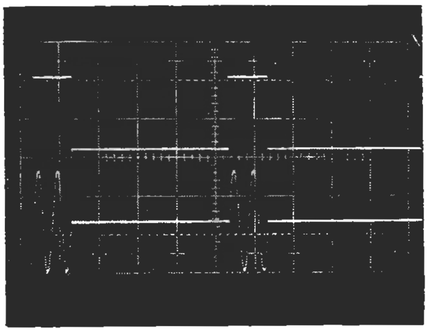


Fig. 2

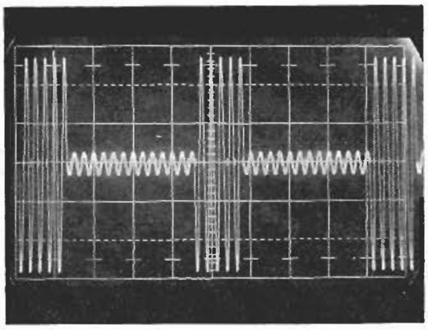


Fig. 4-a

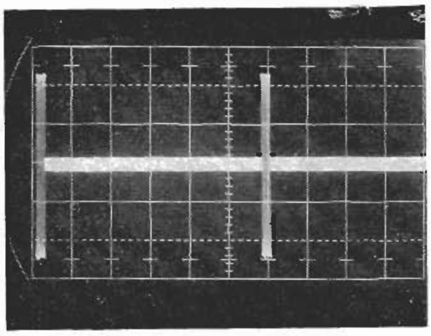


Fig. 4-b

FIG. 2—TONE BURST AND SYNC PULSES, lower and upper traces, respectively. The leading (positive-going) edge of sync pulse is usually used to sync scope.

FIG. 4-a—TONE BURST switched between two levels without reaching zero. (b)—TEST SIGNAL for an audio compressor. (c)—COMPRESSOR OUTPUT when fed with a tone burst like that in Fig. 4-b.

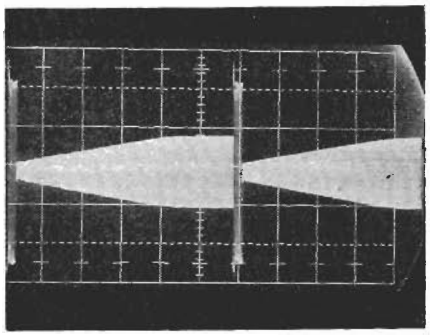


Fig. 4-c

14 Ways To Use R-E's Tone-Burst Generator

Here's a new way to test all kinds of electronic equipment with a new kind of test instrument

by TOM ANNES

TESTING WITH TONE BURSTS IS A TECHNIQUE that is starting to come into use. This technique consists of subjecting a piece of equipment to an ac transient or tone burst and observing the results on an oscilloscope.

There are two basic methods of generating tone bursts. The first method is to use a voltage-controlled oscillator. Turning the control voltage on and off causes the oscillator to turn on and off to create a tone burst. This technique is used to give tone burst capability to some models of commercially available function generators.

The second method is to use a gate to control the output of existing oscillators and waveform generators. This technique was chosen for a future construction article in this magazine. The reasons for this choice are: (1) it can be used to gate any type of waveform generator that you may have on hand, even a noise generator; and (2) it is a more versatile unit yet lower in cost.

Controls and their uses

Let us now learn the controls and their uses. Fig. 1 shows the front panel of the instrument we built last month. (**Radio-Electronics,** July 1971, page 22.) The center knob selects the voltage level on the input waveform where gate opening and closing takes place. It also serves as the power switch. Below this is the TRIGGER SLOPE switch. This little slide switch selects which slope (positive or negative going) is used for gate switching. The two knobs on the right control the period between the start of successive bursts. The one on the far right is the vernier. The bar knob selects the range. This control also has a SINGLE-BURST position. In this mode of operation, the generator produces only one burst and then stays off until reset. Resetting is done by applying a ground or a positive pulse to a BNC jack on the rear panel.

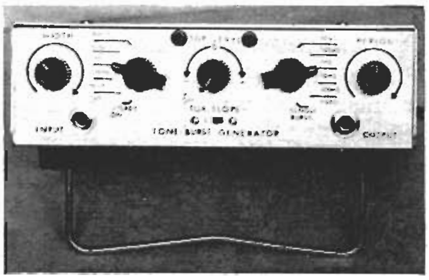


FIG. 1—TONE-BURST GENERATOR you studied and built last month. Now, you are ready to try its multitude of uses.

The two controls on the left control burst width. They are set in the same manner as the period control. The STEADY ON position overrides all other controls and close circuits (closes) the gate. If the PERIOD switch is set to SINGLE BURST, the output will be turned off if the WIDTH switch is in any position other than STEADY ON. This gives good on-off control for setting levels.

The status of the gate is indicated by the red and green traffic lights on the front panel. In actual operation, the intensity of these lamps give an indication of the time on, time off ratio of the gate.

Figure 2 shows the time relationship of the sync pulse and the tone burst.This pulse is available at the back panel for oscilloscope triggering. Setting the oscilloscope to trigger on the positive slope will start the sweep at the start of the tone burst.

The other controls on the rear panel are an INTERNAL-EXTERNAL SYNC selector switch, a SYNC INPUT jack, and a PEDESTAL NULL control. This PEDESTAL NULL control is used to balance out any change of dc output voltage between gate open and gate closed condition.

1. Compression amplifiers

Compression amplifiers, also known as regulated-output amplifiers, have several characteristics that are very easily checked with tone bursts. They are:

1. **Attack Time:** The time required for the compression circuits to take hold and reduce the gain.

2. **Overshoot:** The amount the amplifier output momentarily exceeds the reference or regulation level.

3. **Settling Time:** The time required for the output to stabilize after the amplifier is subjected to signal that exceeds the regulation level by some specified amount.

4. **Recovery Time:** The time required for the amplifier gain to recover after removal of a signal that exceeds the regulation level by some specified amount.

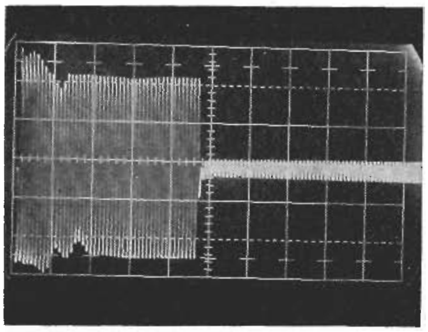


Fig. 4-d

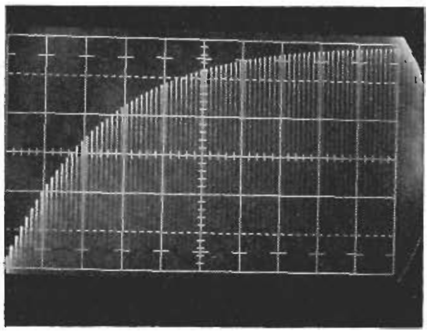


Fig. 6-a

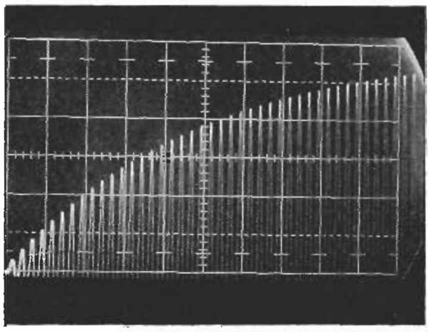


Fig. 6-b

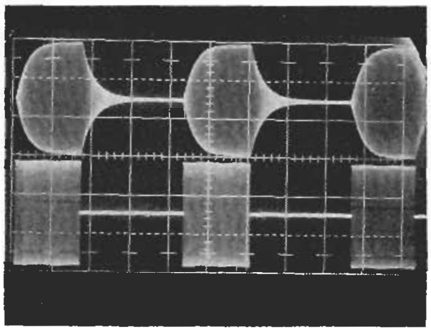


Fig. 5

FIG. 4-d—EXPANDED TRACE simplifies measuring the overshoot and settling time.

FIG. 5—DUAL-TRACE DISPLAY shows output of burst generator at the bottom and the output of a tuned filter at the top. Sweep speed is 20 msec/cm.

FIG. 6-a—RISETIME of compressor amplifier can be read on expanded trace. (b)—FURTHER EXPANSION of filter output trace simplifies Q measurements.

To make these tests, the amplifier must be subjected to a tone burst that is switched between two levels rather than on and off. To produce a tone burst that switches between two levels, use the hookup in Fig. 3. The potentiometer bridged between the input and output may be any value from about 1000 ohms and 1 meg. Output is taken between the wiper arm and ground. The output level between bursts is adjusted by the wiper position; however, it doesn't appreciably change the burst amplitude. If a fixed resistor is added at the point marked "X", the maximum output between bursts will be reduced. This makes adjustment of the potentiometer easier for lower levels. The output at the wiper arm should work into a reasonably high impedance. (A 50-ohm load would look like a short circuit to a 1-meg potentiometer.) Keep the leads between the potentiometer and the tone burst generator short.

The waveform in Fig. 4-a is of a tone burst that switches between two levels rather than going to zero between bursts. This type of waveform is needed when checking amplifier recovery characteristics. It can only be generated by gating-type tone-burst generators. Fig. 4-b is a 1-kHz input signal to a compression amplifier under test. There is a 20-dB signal reduction between bursts. Sweep speed is 0.2 sec/cm.

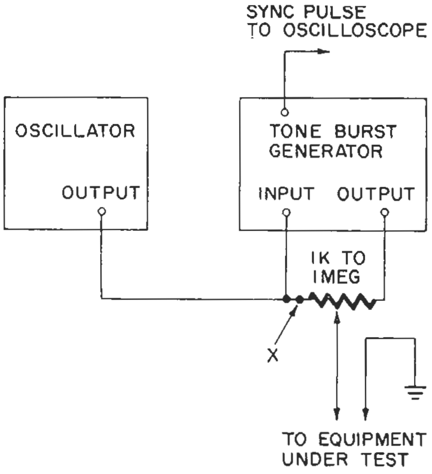


FIG. 3—GENERATOR HOOKUP for developing a burst that switches between two levels. Output is from arm of pot.

The output of the compression amplifier is shown in Fig. 4-c. The voltage between bursts increases 12 dB over the level directly following the burst. The recovery time is about 0.7 second for full recovery of gain. Quite often, recovery time is considered as the time required for the amplifier to recover 63% of the gain it lost. The trace in Fig. 4-d is the waveform in Fig. 4-c expanded to 10 msec/cm to show the burst. Overshoot and settling time are easily measured. The attack-time was so fast that even the first cycle was held down in amplitude.

2 & 3. Bandwidth and Q

Tone-burst testing is a very rapid and accurate method of measuring the bandwidths of tuned filters and amplifiers. Since the results are displayed on an oscilloscope, the effects of adjustments are immediately apparent. This permits more rapid and accurate adjustments to equipment.

The basic concept used in this technique is the relationship between the risetime and the upper 3-dB point of a pulse amplifier. This is expressed by the relationship: Frequency $= 0.35/T_r$, where T_r (risetime) is the time required for the amplitude of a pulse to rise from 10% to 90% of its final value.

If we look at a tone burst as a pulse-modulated carrier, then we can measure the risetime of the burst after passing through an amplifier and compute the bandwidth. Remember that we are talking of a modulated carrier. This means that the calculated value is the bandwidth each side of center or carrier frequency. This value has to be doubled to get amplifier bandwidth.

The lower trace of Fig. 5 shows the input to a tuned filter resonant at 4 kHz. The upper trace shows the output.

Figure 6-a is the upper trace of Fig. 5 greatly expanded. This permits an accurate measurement of the risetime of the output, which is 11 milliseconds. Dividing this into 0.35 (a rounded-off approximation) gives us 31.8 cycles as the bandwidth each side of center frequency. Doubling this gives us a bandwidth of 63.6 cycles.

To measure the Q of a tank circuit, connect the tank circuit across the vertical input of the oscilloscope. Couple the tone burst output to the tank circuit with a 1 or 2 turn loop and a current limiting resistor per Fig. 7. Use the largest value resistor you can and still get adequate vertical deflection on the oscilloscope. This minimizes loading.

Tune the oscillator frequency to give maximum amplitude. Adjust the burst width to a value great enough to permit the amplitude of the burst to reach a steady value. Make the period long enough to let the voltage decay to zero between bursts. Count the number of cycles and estimate the fractional part of a cycle to reach the 63.2% point. Multiply this number by π (3.1416) to find the Q.

The 63.2% point doesn't fall on a graticule line, this alternate method is more convenient: Count the number of cycles to the 50% point and multiply by 1.45 to find the equivalent number at the 63.2% point. Then multiply by π to find the Q.

Figure 6-b is Fig. 6-a expanded for this Q measurement. The 14th positive peak falls exactly on the horizontal center line or 50% point. However, there is only ¾ cycles to the first positive peak.

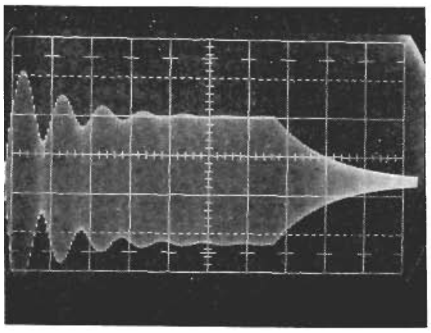


Fig. 8

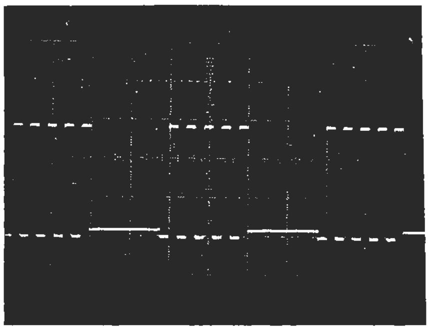


Fig. 9-a

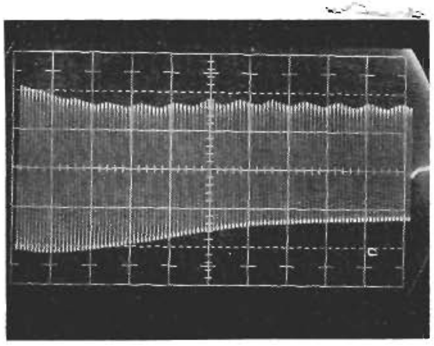


Fig. 9-b

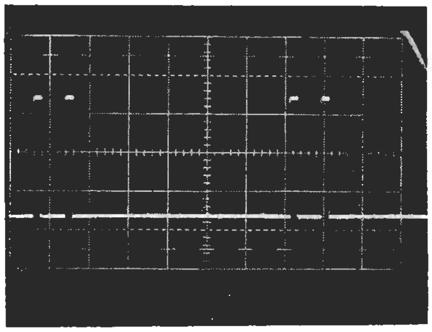


Fig. 10

FIG. 8—OFF-RESONANCE WAVEFORM resulting from feeding 4.2-kHz burst into a 4-kHz tank. Ringing on burst has a period of 5 msec whose frequency equals the difference between the tone burst and the excitation frequencies.

FIG. 9-a—BURST INPUT LEVEL raised just to clipping point. (b)—LENGTHENED BURST causes amplitude distortion as the B+ drops under sustained signal.

FIG. 10—PULSE GENERATOR OUTPUT gated into pulse pairs by the tone-burst generator. Pulses are 10 nsec wide.

Tone-Burst Generator

Thus 13¾ cycles to the 50% point. Q = 13.75 x 1.45 x π = 62.6.

The bandwidth measurements of the resonant filter and the Q of the resonant circuit should jibe because they are the same circuit and components. The bandwidth of a resonant circuit equals Frequency/Q. At 4 kHz center frequency, the bandwidth figures out to be 63.8 cycles for a Q of 62.6. This is less than 1% off from 63.6 cycles, the bandwidth calculated from risetime measurements. Close enough to prove the validity of these techniques.

Whenever a tuned circuit is excited by a tone burst that is not at its resonant frequency, the results will be something like Fig. 8. The damped ringing has a period that corresponds to the frequency difference between the tone burst and the resonant frequencies. In most cases, this method of measuring how far you are off resonance is easier and more accurate than trying to read the oscillator dial.

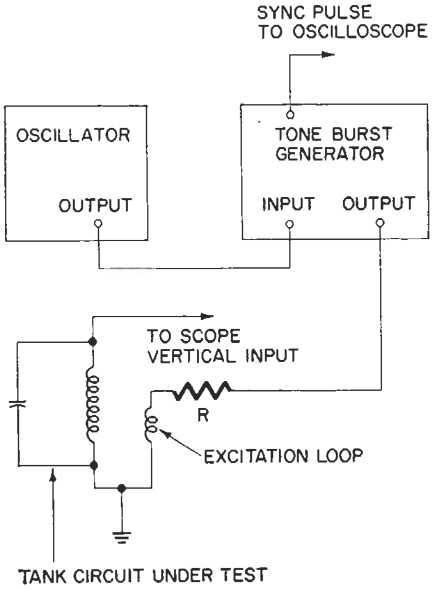


FIG. 7—L-C TANK CIRCUIT as set up for Q measurement. R should be as high as practical to reduce circuit loading.

Quite often, an oscilloscope with triggered sweep and calibrated sweep speeds may not be available. These measurements may still be made with the lower-cost service scopes by making use of the following points. All time measurements may be made by counting the number of cycles between the points of interest (e.g. 10–90% points for risetime measurements) and multiplying by the period of 1 cycle.

Period equals 1/frequency.

If the scope sweep cannot be synchronized to start with the tone burst, measure the fall time rather than the risetime of the burst. With Q measurements, count the number of cycles to decay to 36.8% amplitude rather than rise to 63.2%.

4. Music power rating

There are several methods of rating the power output of audio amplifiers. The oldest and most common is to list the maximum rms power delivered to a load, without distortion exceeding a specified amount. Some manufacturers, in order to make their products look better, started using the *peak power* method. This method computed power from the *peak* rather than the *rms* voltage of a sine wave, thus giving the amplifier a power rating twice that of the true rms power rating.

Another power rating system has now come into use. This is the *music power* rating. This power rating system is based on the fact that many amplifiers can deliver more power than the rms power rating. However, they cannot sustain this power output level; the power-supply voltage sags off under the heavy drain of full output. This power is usually about 20% to 50% greater than the rms power rating.

To measure this power rating, inject into the amplifier a short duration tone burst. (3 to 5 cycles of 1 kHz every 20 msec) While observing the amplifier output on an oscilloscope, increase the amplitude until 5% distortion is indicated. Measure this voltage with the oscilloscope and compute the rms power as if the amplifier were able to maintain this power.

In practice, distortion at maximum power levels is usually caused by peak clipping. Since distortion increases very rapidly after clipping starts, the point of discernible clipping can be called the maximum power point.

Figure 9 shows the results of tests run on an amplifier rated at 25 watts rms or 35 watts music power. The 25-volt output was terminated in a proper load of 25 ohms. A short 1-kHz burst (Fig. 9-a) was used to adjust the output level to 35 watts where clipping was just discernible. The tone burst was then lengthened to 100 msec once every second. The oscilloscope trace in Fig. 9-b shows how the output goes to pot. This amplifier is normal. It just requires a tone burst to check it out. Vertical scale is 20 volts/cm; horizontal scale is 10 msec/cm.

Pulse bursts and pairs

This tone-burst generator, though designed for home construction, has a very good transient response. The rise and fall time is about 170 nanoseconds, without any overshoot or ringing. This makes it well suited for gating pulse generators.

The gating of a pulse generator produces pulse bursts, a signal form needed for testing some types of pulse equipment. However, if the number of pulses in a burst are reduced to two, you have a pulse pair generator (Fig. 10). This is a *must have* type of signal when working with pulse-spacing decoders.

The spacing between pulse pairs is adjusted by the tone-burst generator period controls. But, the pulse generator period control adjusts the spacing of the

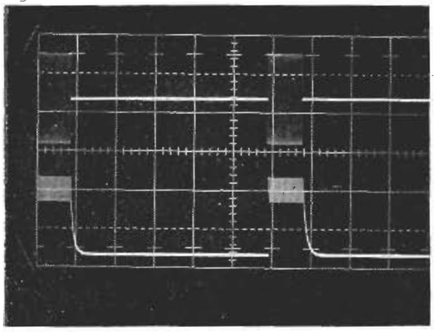


Fig. 11

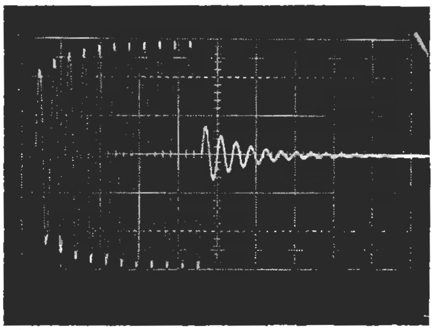
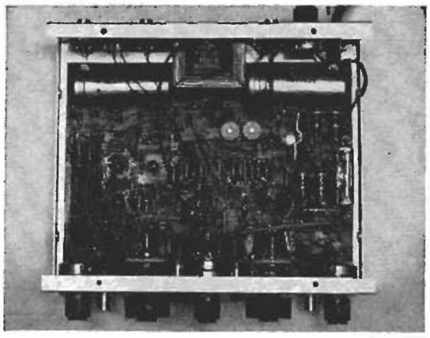


Fig. 13



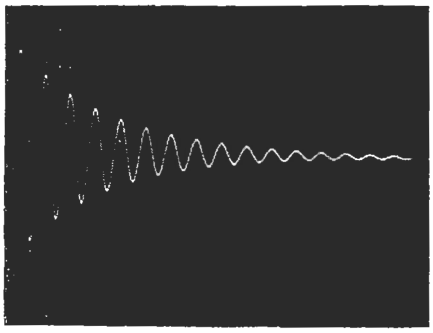


Fig. 12

FIG. 11—UPPER TRACE is 50-kHz input to a detector; lower trace is output.

FIG. 12—SINEWAVE decaying at an exponential rate is used to determine writing rates of scope and photo films.

FIG. 13—VOICE-COIL VOLTAGE of a 4-inch loudspeaker showing room/speaker resonance at approximately 255 hertz.

INSIDE VIEW OF BURST GENERATOR (top right) shows how instrument will look if you followed the construction details and layout given last month.

pulses in the pair. **NOTE:** If the spacing of the pulses in the pair must be varied over a large range, the tone-burst generator width control may have to be adjusted to maintain two pulses. Triggering slope should be set to trigger when the pulse voltage is returning to zero volts. For example, on a positive pulse, trigger on the negative-going or trailing edge. If you trigger on the positive or leading edge, the last pulse in the burst would end the burst and make a spike of itself.

5. Detector circuits

Another use for this versatile instrument, is checking detector circuits. Figure 11 shows the performance of a detector circuit under test. The upper trace shows the tone burst fed to the detector. The lower trace shows the detector output. Frequency response can easily be determined by measuring the falltime of the recovered signal and computing bandwidth. Falltime is used rather than risetime because it is longer.

6. Frequency division

On occasion, there is the need for a frequency divider. The timing circuits in this tone burst generator are very stable. This feature permits frequency division of at least 100. Whenever an input signal is being gated, the burst-repetition frequency is a subharmonic of the frequency in the burst. The sync pulse available on the back panel is at the burst-repetition frequency.

In actual practice, the input frequency may be anything up to 5 MHz or higher. The divided output frequency is controlled by the period controls. They can be set to anything between 1 Hz and 100 kHz. The width controls may be set to anything less than the period controls.

7. Photographic writing speed

When photographing single-sweep displays on an oscilloscope, it is necessary to know the writing speed of your oscilloscope, camera and film combined. *Writing speed* is defined as the fastest spot velocity that can be recorded on film on one trace. This is usually given in centimeters per microsecond.

One way that this can be measured is to photograph a decaying sine wave, the frequency and amplitude of which is high enough that only the peaks of the first few cycles show up on the film. Inspect the photograph to determine the first two peaks that have a discernible line between them. Measure the vertical distance between these peaks and compute the writing speed. Writing speed equals π DF. Distance (D) is in *centimeters* and frequency (F) is in *megahertz*.

This decaying waveform is produced across a resonant tank at the end of a tone burst (Fig. 12), and displayed by triggering the scope on the negative or trailing edge of the sync pulse out of the tone burst generator.

8. Loudspeaker testing

Whenever a steady audio tone is fed to a loudspeaker or any other transducer, resonances enter the picture. These resonances are caused by reflections in the room or baffle. When a loudspeaker is excited by a tone burst, the first cycle will be unaltered by reflections. As the burst progresses in time, the effects of reflections will show up. This permits the identification of resonance conditions and enables you to do something about them.

In actual practice, the tone-burst generator itself is used to drive the speaker. A resistive matching pad must be used between the speaker and the tone-burst generator output. The voltage directly across the voice coil is fed to the oscilloscope. **NOTE:** Do not try to feed the speaker from an amplifier directly. The very low output impedance of the amplifier will swamp out these resonance conditions you are seeking to locate.

9. Speaker impedance

It is possible to measure the free-space impedance of a speaker or other transducer in the presence of reflections. This is done as follows: Feed the tone burst through an attenuator pad to the speaker under test. This pad must have 20 dB or more loss. (With this much loss, the speaker will think it is being fed from a source that has an impedance very close to the impedance of the pad.) Make two voltage measurements. First, measure the voltage out of the pad without the speaker connected. Next, connect the speaker to the pad and measure the voltage of the first cycle of the burst. Now, take these voltages, along with the pad impedance, and plug them into the formula

$$Z_s = \frac{E_s \times Z_p}{E_o - E_s}$$

Z_s = Speaker impedance
Z_p = Pad impedance
E_o = Open-circuit voltage
E_s = Voltage across the speaker

Note that the voltages end up as ratios. This means that you don't have to have an accurately calibrated scope for this measurement. However, the impedance of the pad must be known. It should also be close to the impedance of the speaker under test.

10. Echos

The tone-burst generator is an ideal source of pulses in any type of echo research or experiment. Because these pulses or bursts are phase coherent, very accurate reflection times may be measured. This is done by cycle matching (comparing the phase of the cycles in the returned pulse to the outgoing pulse). Typical applications would include things like ultrasonics, sonar, acoustical radar and round-trip time and return-loss measurements in communication land lines.

(continued on page 85)

USING THE TONE-BURST GENERATOR

(continued from page 35)

11. External timing

The switching of the gate may be synchronized with something other than the gated signal. This is easily done by feeding a timing signal into the SYNC INPUT jack on the rear panel. The INTERNAL-EXTERNAL SYNC selector switch on the rear panel must be switched to the EXTERNAL position. Input impedance will be about 5000 ohms.

This mode of operation is handy for gating signals that are random or sporadic in nature. The gating of a noise generator to create noise bursts is a good example.

The tone-burst generator can be used as a pulse generator by feeding dc into its input and triggering or gating externally. The pulse width of the output equals the on gate-time and the time between pulses equals the setting of the PERIOD control. The pulse amplitude and polarity are controlled by the dc voltage fed in.

12. Power-line transients

Controlled power line transients are useful when developing or testing line-noise filters, regulated power supplies, ac-dc converters, etc. Figure 14 shows how the tone-burst generator and a high-power amplifier are used to superimpose transients on the power line. Stepdown transformer T1 feeds burst generator input. The burst is amplified and fed to power line through buck-boost transformer T2. Transformer T2 may not be needed if the amplifier output is transformer coupled.

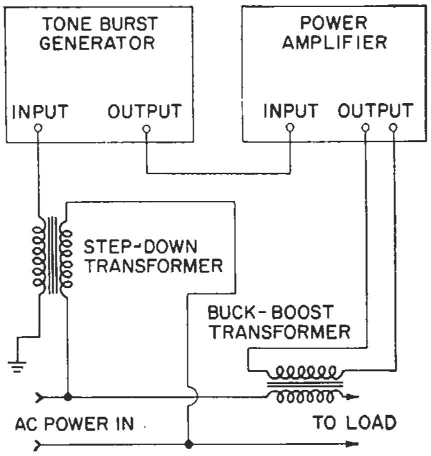


FIG. 14—CONTROLLED TRANSIENTS on power line can be developed by using tone-burst generator in conjunction with a high-power audio amplifier.

13. Single burst operation

For some uses, it may be desirable for the operator to initiate bursts on command. This is done by placing the PERIOD switch in the SINGLE-BURST position. Every time the RESET jack is grounded, a single burst will be initiated by the internal sync circuits. This grounding is best done with a hand-held, push-button switch connected to the RESET jack with a cable.

A positive pulse of at least 1 volt into the RESET jack will reset the tone-burst generator. This feature enables external equipment to control the burst-repetition rate. An example of such a use would be the generation of standard time ticks.

14. Standard time ticks

Standard time ticks are tone bursts of about 5 cycles of 400 Hz or 1 kHz audio every second. These are often used for time-reference marks on data recorders. Radio station WWV is a good source. However, the need may arise for time ticks of a different length, frequency or repetition rate than those available from WWV. The tone-burst generator can fill this need very nicely.

To generate time ticks with the burst generator, set the PERIOD control to SINGLE BURST. Into the RESET jack, feed in a reset pulse at the desired repetition rate. Feed the signal to be converted into ticks into the input. Use internal sync. The cycle count in the tick is controlled by the WIDTH controls. **NOTE:** The reset pulse just arms the circuits, so to speak. The signal to be gated actully starts the burst. In order to prevent a time jitter of the ticks, the reset pulse and the signal to be gated must come from the same frequency source.

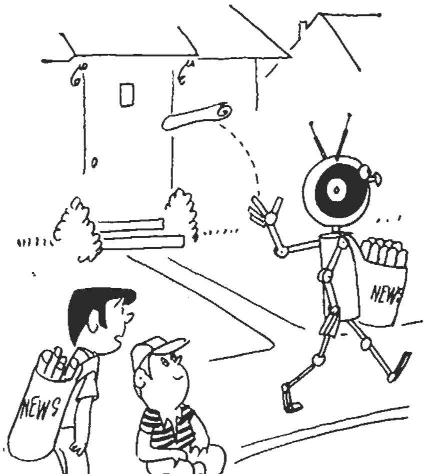
Slow repetition rates

Burst repetition rates of less than 1 burst per second is possible. This is done by placing the PERIOD control in the SINGLE BURST position. A positive pulse at the desired repetition rate is fed into the reset jack. The tone bursts generated will still be phase coherent because the gated signal itself switches the gate.

Summary

This article shows some of the many applications of the tone-burst generator. These are by no means the only things that can be done with this versatile instrument. As more people learn about them, their scope of application will greatly broaden. **R-E**

Another test instrument you'll want to build is a function generator. The complete article on this solid-state instruments appears in the October 1971 issue.



"I wish my dad would build one for me!"