IC Tone Burst Generator

Part II: How it works and how to build it

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HAVING DISCUSSED the general theory behind our IC tone burst generator last month, this month we will get down to specifics: namely a working schematic, details of circuit operation, and a parts list. The complete generator with all its options is an extremely flexible instrument. However there are a number of circuit features which can be deleted if you don't need all the performance of the full-blown version. At any rate, here it is in its entirety—you may carry your own version as far as you desire or your electronic larder permits.

Figure 1 is a functional block diagram which illustrates how the unit is laid out, the input/output signals, and the signal flow path. The input signal is first buffered after entering the instrument, then branched into two paths; one via the synchronizer and one via the switch itself. The processed output of the synchronizer gates the switch ON-OFF to establish a tone burst, and an output amplifier buffers this signal to feed the outside world. An internal power supply feeds the various circuits regulated ±12 volts and +5 volts, also unregulated plus and minus potentials of about 20 volts.

The actual circuitry which accomplishes these functions can be segregated into three main areas, the switch and its associated circuits, the synchronizer and its details, and the power supply. Let's look at them now in that order.

The MC1496G Electronic Switch

The heart of the tone burst electronics is the balanced modulator switch, the MC1496G, which we discussed last month. Figure 2 shows how it is used in this application. The details differ slightly from our general model of last month, but the basic idea is still the same.

Beginning at the input of the instrument (JI) the signal is buffered by IC1, an op-amp connected as a unity gain voltage follower. The input impedance of this connection is very high due to the 100% voltage feedback, so the 47K resistor R1 serves as the sole determinant of input impedance. The low impedance buffered signal at IC1's output splits into two paths; the route through the switch itself and the synchronizer path (output AA). For the moment we'll not regard the synchronizer signal and follow the signal flow through the switch.

The signal from IC1 is applied to IC2 by two paths. REa or channel A drives IC2-Q5's emitter on pin 3. Likewise REb or channel B drives IC2-Q6's

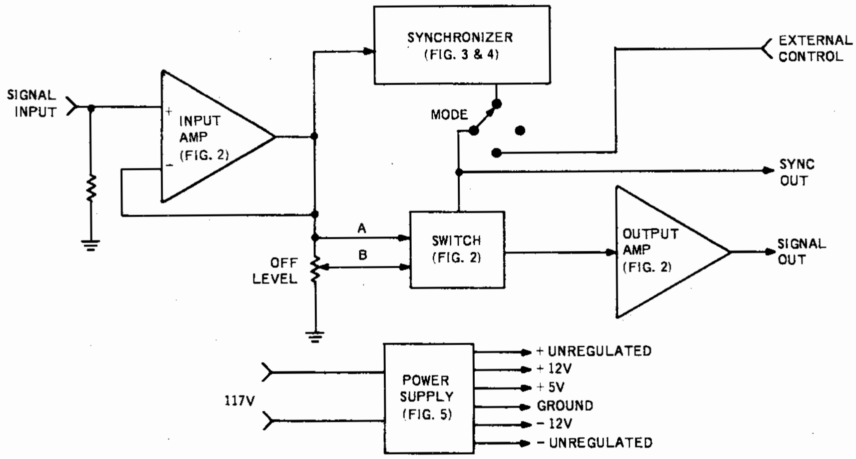


Fig. 1—Block diagram of IC tone burst generator.

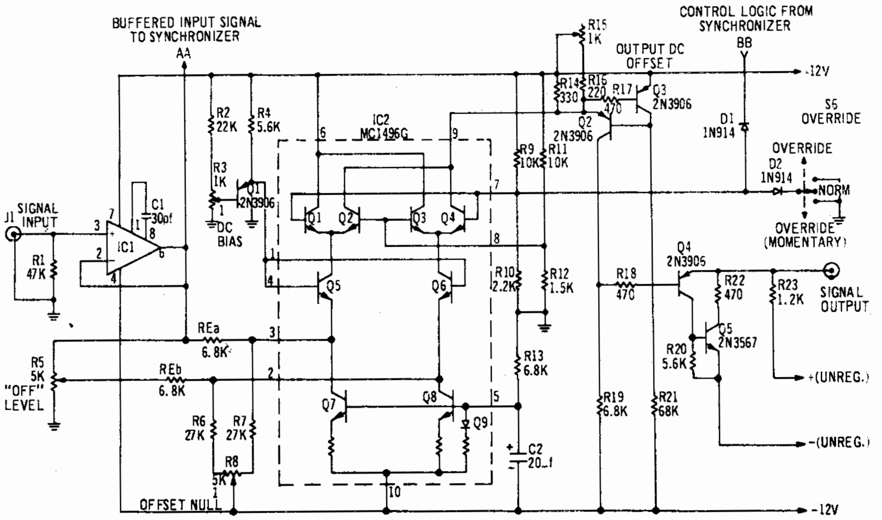


Fig. 2—Schematic diagram of input amp., switch, and output amp.

emitter via pin 2, with the channel B level variable by adjustment of OFF level pot R5. The two switching channels of IC2 operate with IC2-Q5 and Q6 in the common base mode. The connection minimizes crosstalk and maximizes both dynamic range and linearity.

To enable the audio signals to be d.c. coupled through IC2 it is necessary to offset the Vbe of IC2 Q5 and Q6. To accomplish this, a positive d.c. bias is used on their bases (pins 1 and 4) from Q1. This level is variable from R3 and is trimmed so the emitters of IC2-Q5 and Q6 rest at zero volts d.c., thus facilitating d.c. coupling through REa and REb. In addition Q1 provides a very low source impedance, eliminating the common base connection as a possible source of crosstalk.

To eliminate any possible mismatch between the d.c. currents of channels A and B, a differential current balance network is used in the IC2-Q5 and Q6 emitters. This consists of R6, R7 and trimmer R8. R8 is set up initially to adjust the current offset to zero and needs no further adjustments.

The switching of the IC2-Q5 and Q6 collector currents is just as discussed last month. A fixed d.c. bias is applied on pin 8 from R11-R12 and the pin 7 potential switched to control the state of the switch. In the quiescent state the d.c. bias from R9-R10 holds pin 7 slightly higher than pin 8, which in turn connects the output at pin 9 to source B. When a LOW control logic signal from the synchronizer is applied through D1, pin 7 is pulled low with respect to pin 8: this transfers the switch output to source A. Since in this application only a single output from pin 9 is desired, the opposite side of the switch (pin 6) is a.c. grounded by tying it directly to the +12 V. line.

The signal output from pin 9 does not drive a load resistor directly, but is applied to level shift converter Q2-Q3. This stage translates the high d.c. baseline of pin 9 back down to a zero volt average potential at the top of R19. So we can now have a signal d.c. coupled all the way through the instrument, be switched, and then appear at the output with no d.c. offset, and also no interaction between control signal and output due to RC time constants.

A complementary output buffer, Q4 and Q5, buffers the relatively high impedance of R19 and enables the generator to drive ±5 volts into 500 ohms at the output jack J4. Current limiting is provided by R23 (positive swing) and R22 (negative swing). Since this output stage is a local d.c. feedback loop in itself (and thus immune to ripple and supply variations), it

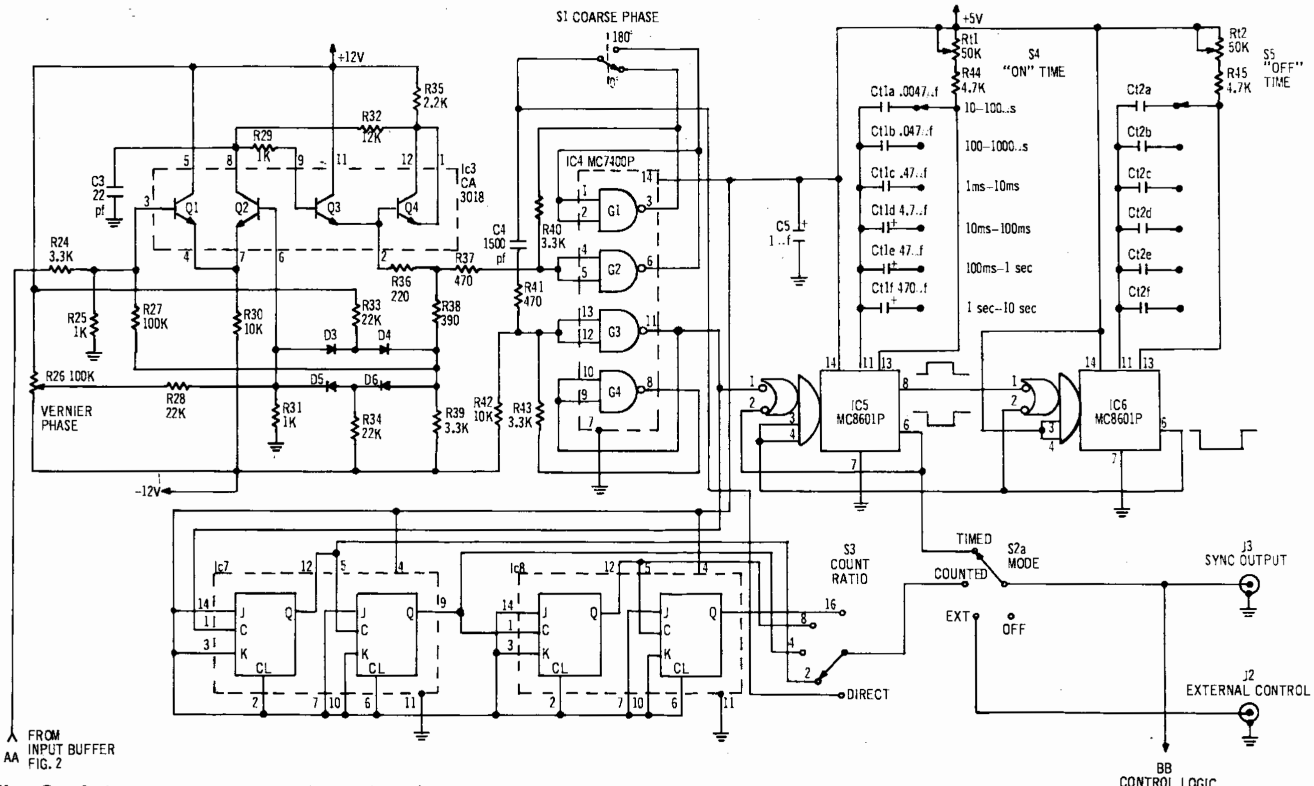


Fig. 3—Schematic diagram of synchronizer.

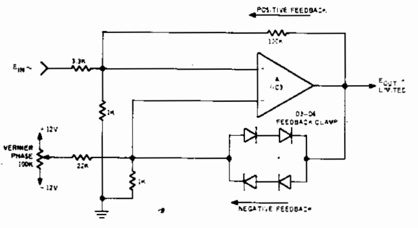


Fig. 4—Functional diagram of IC3 limiter circuit.

is operated from the unregulated + and – lines with no sacrifice in performance.

If we go back to the level shift stage of Q2-Q3 for a moment we can see how this stage adds a measure of versatility to the instrument. The basic requirement of this stage is to cancel the positive voltage offset across the switch IC2. But since this stage is also a local d.c. regulator it can do more than this. By adjusting the d.c. current in Q2 the voltage at the output can be made to rest statically not only at zero volts d.c., but also above and below ground. In either case the signal current from IC2 will linearly be summed atop this d.c. level. So the net result is that by making R15 a front panel control (to adjust Q2's d.c. current) the base line offset can be adjusted to zero or any voltage within the dynamic range of the unit (±5 volts). This greatly enhances the flexibility of the device as it can be used to "build up" special waveforms to drive logic stages or linear amplifiers using the d.c. component for bias and adding the signal component by appropriate control settings to the switching stages.

The switching signal from the synchronizer logic stages is applied through one leg of a diode "or" gate D1-D2. With the S6 override switch in its normal position (center), a low signal from the synchronizer implements channel A of the switch though D1. At any time S6 can be used to override this switch control and force the switch on, either momentarily (down) or continuously (up). This allows a fast check of the input, as it will allow any input signal to appear at the output regardless of any other switch settings.

Now let's follow that signal out of AA and see how it is processed by the synchronizer.

The Synchronizer

Last month you'll recall we went into the timing requirements and functions of the synchronizer. The circuitry which accomplishes all of this is Fig. 3. The limiter is IC3, a CA3018 monolithic transistor array connected as a differential input op-amp. IC3 and its associated circuitry is functionally equivalent to Fig. 4. Here the IC is represented by the general amplification symbol, A. The diodes in the negative feedback loop limit the output voltage to ± two junction drops over a wide range of input signal amplitude due to their logarithmic forward voltage characteristic. You'll also note that there is a positive feedback path through the 100K resistor. This gives the circuit a 10 mv hysteresis which provides a clean sharp switching action above its threshold. A variable d.c. bias inserted in the negative feedback loop by R26 allows the limiting process to be displaced above and below the zero axis on the slope of the input sine wave. This provides a vernier phase control of ±90 degrees with a 2 V. p-p input signal. With the phase control set for 0 degrees (maximum sensitivity) this circuit will deliver a constant output with no phase changes over more than 50 dB range on input amplitude variation.

The output of the limiter directly feeds a TTL logic gate Schmitt trigger IC4-G1/IC4-G2) which shapes the limiter output into a fast rise-time rectangular wave with a choice of either 0 or 180 degrees phase relation with respect to the input sine wave. This coarse phasing adjustment is selected by front panel switch S1. The output of this switch feeds IC4-G3/IC4-G4, which is a modified Schmitt circuit (similar to the above) biased in the low input state by R42. When a positive going input appears at C4, the C4-R41 time constant will raise the input to IC4-G3 momentarily and drive the output of IC4-G3 low. A low input to IC4-G4 causes its output to go high which reinforces the original positive transient from C4. As the input pulse decays back towards ground due to the a.c. coupling, IC4-

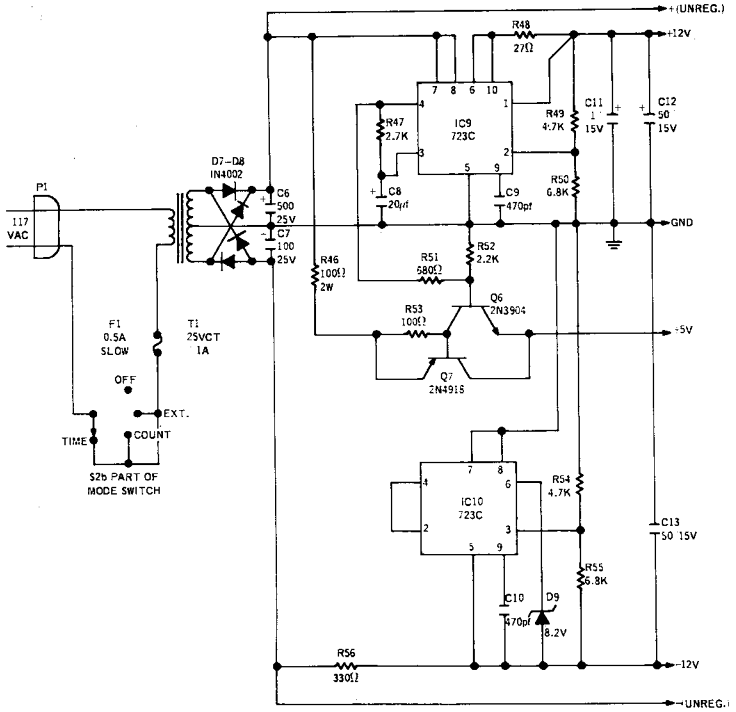


Fig. 5—Power supply.

G3's threshold is reached, and the regenerative action reverses itself, terminating the negative 4 microsecond pulse at IC4-G3's output.

This 4 microsecond pulse serves as a master timing reference for the synchronizer, and clocks both the timing and counting circuits, which will be described next.

The counter circuits of the synchronizer use 2 MC7473P JK flip-flops, IC7 and IC8 connected as a divide-by-16 counter. Output taps are available at division ratios of 2, 4, 8 and 16, allowing any of these count ratios to be selected by COUNT RATIO switch S3. Also available at this switch is a DIRECT position which provides the rectangular wave available at the arm of S1. This position allows fractions of a cycle to be gated. The output of the COUNT RATIO switch feeds MODE switch S2.

The variable ON-OFF timing circuitry of this tone burst generator is comprised of IC5 and IC6 and the switch selected timing components Ct1-Rt1 and Ct2-Rt2. Last month we saw how these two IC monostable multivibrators make up a wide range semi-synchronous timer with independently variable on and off times. Both timers are identical, so a description of one should suffice to illustrate the principle.

The IC used is the MC8601P which is a wide range, directly triggered one-shot multivibrator with both retriggering and gating capability. It generates an output pulse of a duration 0.32 RtCt. As it is used here, all inputs must be HIGH for it to trigger when a negative pulse is received at pin 1. Before the first trigger pulse occurs, pins 2, 3 and 4 of IC5 are held HIGH by the feedback from IC5 pin 6 and IC6 pin 6. A negative pulse at IC5 pin 1 starts the timing cycle: pin 8 switches HIGH and pin 6 goes LOW. The LOW signal from pin 6 to 2 locks out the input gate and prevents further triggering. The duration of IC5's output pulse length will be determined by the timing components of Ct and Rt, where Ct is the capacitor selected by S4 (ON time) and Rt is the total resistance of Rt1 + R44. The pulse width will be equal to 0.32 RtCt. Rt1 and R44 serve as a vernier time adjustment with slightly over a 10/1 range, and Ct1a-Ct1f provide decade variations to give a total range of time adjustment from 10 microseconds to 10 seconds. The negative output pulse (pin 6) from IC5 serves as the output of the timer and will hold the audio switch ON for the duration of the pulse width.

The negative trailing edge of IC5's positive output pulse (pin 8) triggers IC6 which uses a similar timing circuit, Ct2-Rt2, R45. The output pulse width of IC6 determines the OFF time of the timer, since it will inhibit IC5 from any further triggers for the duration of its negative pulse at pin 6. This negative pulse is fed to IC5 pins 3 and 4 and prevents triggering during the low state of IC6 by locking IC5's input gate OFF.

The net result of this combination is an extremely versatile timing combination with no limitation on relative ON-OFF ratios. The MC8601P one-shots are stable enough to allow duty ratios of nearly 100% without deviation from the pulse width setting. You can, for instance, gate ON 99 cycles out of 100, turn OFF for 1 cycle and then repeat the ON for the 101st input cycle. Towards the other extreme the possible ratio becomes even more ridiculous—ON for 10 microseconds (1 cycle of 100KC) and OFF for 10 seconds is quite possible! Suffice it to say that there will be no limitation to the flexibility of the available gate times due to the timer circuits.

The output of IC5 pin 6 is also the output of the timer and appears at position 3 of the mode switch S2. The counter output is available at position 2, thus the term COUNTED. An external source connected to J2 may also be selected by using position 1, EXTERNAL. The output of S2 is made available at J3 as a sync signal for scope connections, etc. The signal at this point is the output of the synchronizer, fully processed for direct control of the audio switch. It drives the switch through D1 of the override gate (see Fig. 2).

Power Supply System

The power supply used consists of a full-wave, center-tapped transformer with capacitor input filters (C6 and C7) feeding complementary 12 volt regulator IC9 and IC10. IC9 is a conventional series regulator configuration using the 723's internal pass transistor. The internal reference of +7.15 volts available at pin 4 is used as a reference source for the 5 volt regulator Q6-Q7 after division by R51-R52.

IC10 controls the negative leg in shunt regulator fashion with its terminal voltage set by R54-R55. This IC acts as a "super zener," absorbing any input current variations through R56 due to a.c. ripple or line voltage changes. It also provides an extremely low source impedance for the −12 volt circuits, a condition necessary for good signal-to-noise ratios to be realized in the switch and amplifier circuitry.

Much of the credit for the excellent signal-to-noise ratio of this tone burst generator is due to these high performance IC regulators and careful filtering. Although the circuit is not overly complex, it is none the less able to deliver a stable ±12 and +5 volts d.c. with ripple less than 500 microvolts. The ±12 and +5 volt supplies are all short circuit protected. Unregulated taps from the plus and minus input capacitors are also brought off for use in the non-critical stages of the generator.

Construction

The tone burst generator was built into a Bud SC-2130 box with front

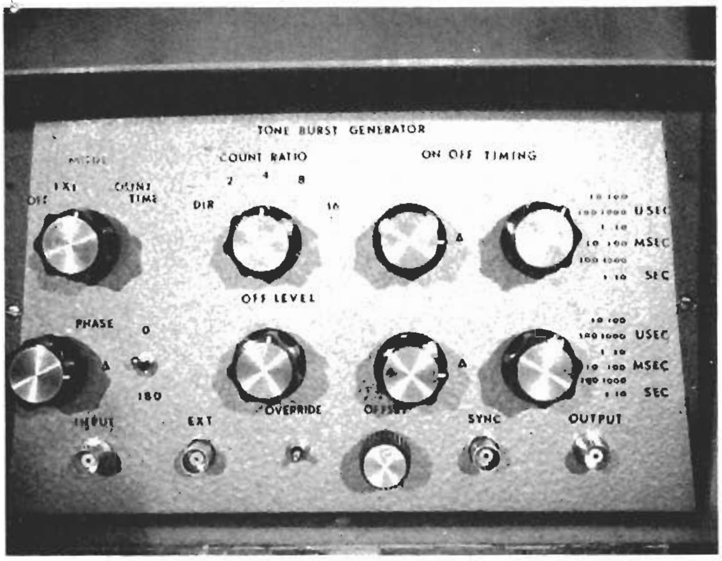


Fig. 6—Front panel layout.

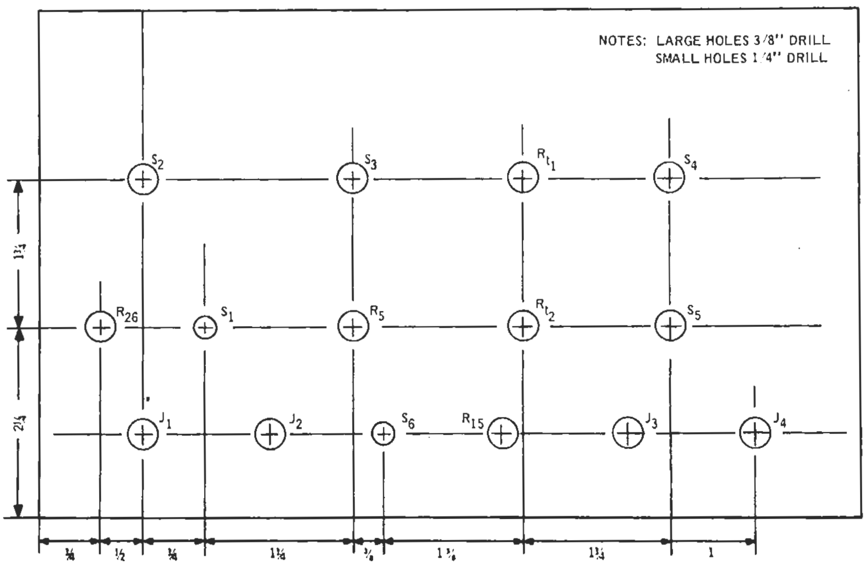


Fig. 7—Front panel layout and drill dimensions.

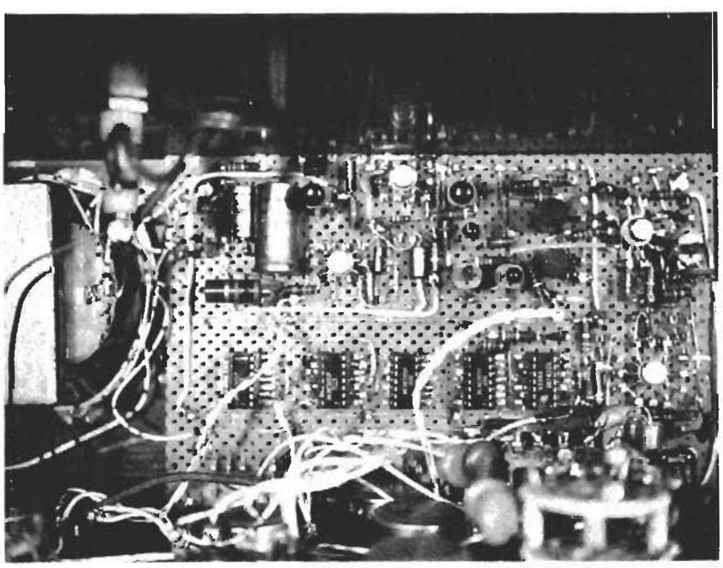


Fig. 8—Internal view.

panel layout as shown in Fig. 6. Should the reader want to duplicate this configuration, a drill template for this layout is included (see Fig. 7). Input/output jacks are arranged J1-J4, left to right. Between J2 and J3 are located the override switch and the offset trim control. The remainder of the controls follow a logical sequence progressing from J1 (input) to J4 (output).

Internal construction is shown in Fig. 8. Here the single 4½ × 6½-in. circuit board and power transformer placement may be noted, as well as the front panel pots and switches.

Perf-board construction was used in the prototype, with the various circuit subsections laid out in segregated areas. Busses for power distribution were used, these may be seen running lengthwise along the board.

The power supply components are in the left rear corner of the board where the secondary leads of T1 connect to the rectifier bridge. The 723 regulators may be seen to the right of the filter caps towards the rear center. Q6 and Q7 are located between the 723's and the capacitors with Q7 near the rear panel. The large resistor in front of the capacitors is R46, which is positioned up and off the board to facilitate heat removal.

In the right rear section are located the MC1496G switch and output amplifier. Trim controls R3 and R8 may be seen in this area also.

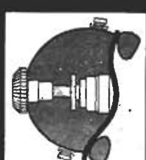
The front section of the board is taken up mainly by the synchronizer circuits. The row of dual-inline IC's are the MC8601p's, the MC7473p's and the MC 7400p. The CA3018 is at the extreme right of the board. IC1 is towards the left end of the board and up front. In this same area are the connections to the switches S2, S3, S4 and S5.

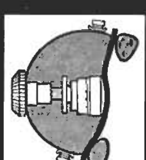
The timing capacitors Ct1 a-f and Ct2 a-f are mounted on the switches S4 and S5 with R44 and R45 connected directly between Rt1-S4 and Rt2-S5.

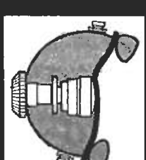
One fact of life which should be pointed out concerning the timing capacitors is the lack of precision tolerances available in reasonably priced instrument such as this. The longer periods where tantalum electrolyties are used may not be exact because of the large tollerances of the capacitors. The values are chosen slightly towards the "low" side to allow padding if necessary with additional small value capacitors. In view of the desired low overall cost this was felt to be a reasonable approach.

Options

At this point we have discussed the entire circuit and the parts list describes the components necessary to build the entire circuit. But, as it was pointed out







in the opening paragraph, you may not want to build in all the features. An obvious breakpoint might be to leave out the counter circuits and use only the timer circuits. After all, any duty cycle provided by the counter circuit can be duplicated by the timer with appropriate control adjustment, and the counter may be regarded as a luxury by some. Pay your money and take your choice.

Another area of possible savings are the longer periods of the timer. If you do not foresee the use for a 10 second gating interval, you can dispense with Ct1f and Ct2f (and save considerable change).

Armed with the above data you are now ready to start rolling on your own IC tone burst generator. A number of IC sources are listed on the parts list, and there should be no problem obtaining devices from the supplies listed. All of the parts are standard.

Next we'll run through a checkout and calibration procedure to aid in proper set up. Then we'll explore some of the many ways you can use a device like this.

(To be continued)

Parts List (Continued on page 81)

Resistors

Ref. Designation	Description	Part Number	Quan.
R1	47k, ¼w, ±10%		1
R2, R28, R33, R34	2k, ¼w, ±1%		4
R3	1k, PC type trimmer	CTS X201R102B	1
R4, R20	5.6k, ¼w, ±10%		2
R5	5k pot, 2W, linear	Ohmite CMU5021	1
R6, R7	27k, ¼w, ±10%		2
R8	5k, PC type trimmer	CTS X201R502B	1
R9, R11, R30, R42	10k, ¼w, ±10%		4
R10, R35, R52	2.2k, ¼w, ±10%		3
R12	1.5k, ¼w, ±10%		1
R13, R19, REa, REb, R50, R55	6.8k, ¼w, ±5%		6
R14	330, ¼w, ±10%		1
R15	1k pot, 2w, linear	Ohmite CMU1021	1
R16, R36	220, ¼w, ±10%		2
R17, R18, R37, R41	470, ¼w, ±10%		4
R21	68k, ¼w, ±10%		1
R22	470, ½w, ±10%		1
R23	1.2k, ½w, ±10%		1
R24, R39, R40, R43	3.3k, ¼w, ±10%		4
R25, R29, R31	1k, ¼w, ±10%		3
R26	100k pot, 2w, linear	Ohmite CMU1041	1
R27	100k, ¼w, ±10%		1
R32	12k, ¼w, ±10%		1
R38	390, ¼w, ±10%		1
R44, R45, R49, R54	4.7k, ¼w, ±5%		4
Rt1, Rt2	50k pot, 2w, linear	Ohmite CMU5031	2
R46	100, 2w, ±10%		1
R47	2.7k, ¼w, ±10%		1
R48	27, ¼w, ±10%		1
R51	680, ¼w, ±10%		1
R53	100, ¼w, ±10%		1
R56	330, ½w, ±10%		1

Switches

Ref. Designation	Description	Part Number	Quan.
S1	Toggle, SPDT miniature (on-none-on)	Alco MST-105D C&K 7101	1
S2	Rotary, double section, 3 positions (+ off)	Mallory 1323L	1
S3	Rotary, single section, 5 positions	Mallory 3215J	1
S4, S5	Rotary, double section, 6 positions	Centralab 1410	2
S6	Toggle SPDT, miniature (on-off-momentary on)	Alco MST-105H C&K 7107	1

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Parts List, (Continued from page 40)

Capacitors

Ref. Designation	Description	Part Number	Quan.
C1	30 pf, ±5%, mica		1
C2, C8	20 μf, 16V, electrolytic	Sprague "TL"	2
C3	22 pf, ±5%, mica		1
C4	1500 pf, ceramic disc		1
C5, C11	1 μf, 35V, tantalum	Sprague "196D" or Kemet "E"	2
Ct1a, Ct2a*	4700 pf, ±5%, mica		2
Ct1b, Ct2b	.047 μf, ±10%, 100V	Cornell Dubilier "WCR" polycarbonate	2
Ct1c, Ct2c	.47 μf, ±10%, 100V	As above	2
Ct1d, Ct2d	4.7 μf, ±20%, 10V	Sprague "196D" or Kemet "E"	2
Ct1e, Ct2e	47 μf, ±20%, 6V	As above	2
Ct1f, Ct2f	480 μf (330 μf and 150 μf in parallel for equivalent value), ±20%, 6V	As above	2
C6	500 μf, 25V, electrolytic	Sprague "TL"	1
C7	100 μf, 25V, electrolytic	As above	1
C9, C10	470 pf, ceramic disc		2
C12, C13	50 μf, 16V, electrolytic	Sprague "TL"	2

*See text.

Semiconductors

Ref. Designation	Description	Part Number	Quan.
D1 - D6	Silicon diode, gen. purpose	1N914	6
D7 - D10	Rectifier, 100V, 1A	1N4002	4
D11	Zener, 8.2V, 500 mw	1N5237	1
Q1 - Q4	Transistor, PNP	2N3906	4
Q5	Transistor, NPN	2N3567	1
Q6	Transistor, NPN	2N3904	1
Q7	Transistor, PNP power	2N4918	1
IC1	Op amp, uncompensated	National LM301A Fairchild μA301A Signetics N53A1	1
IC2	Balanced modulator	Motorola MC1496G Fairchild μA796C Signetics N5596K	1
IC3	4 transistor IC array	RCA CA3108	1
IC4	Quad 2 Input Nand Gate	Motorola MC7400P T.I. SN7400N Signetics N7400A	1
IC5, IC6	Monostable multivibrator	Motorola MC8601P	2
IC7, IC8	Dual JK flip-flop	Motorola MC 7473P T.I. SN7473 Signetics N7473A	2
IC9, IC10	Voltage regulator	Motorola MC1723CG Signetics N5723L Fairchild μA723C	2

Miscellaneous

Ref. Designation	Description	Part Number	Quan.
T1	Power transformer, center tap, 117 V in, 25V out @ 1A	Stancor P8180 Triad F-45X	1
J1 - J4	Jack, BNC panel mount	UG-625	4
F1	Fuse, 0.5A, slow blow, with holder		1
P1	Line cord with plug		1
	IC socket, 14 pin, DIP style	Cinch 14 DIP	5
	Case, aluminum, grey hammertone	Bud SC-2130	1
	Control knobs, ¼-in. shaft, to individual preference		8
	Circuit board, prepunched, with pins	"Vectorboard" 64P44/062EP	1