THE GENERAL RADIO
EXPERIMENTER

A GENERATOR OF AC TRANSIENTS

Tone-burst waveforms are useful signals in many diverse fields of electronics, such as psychoacoustic instrumentation, generation of controlled periodic line transients, and synthesis of the time "ticks" on standard-time radio transmissions. At General Radio, tone bursts have been used in routine tests of filters and ac meters as well as for such unusual purposes as the alignment and test of an instrument for instantaneous frequency analysis of the high-frequency sound emissions of bats.

These waveforms also have many applications in the test and calibration of sonar transducers and amplifiers and in the measurement of loudspeaker distortion and response to transient excitation. Still other uses are found in the measurement of room acoustics, automatic-gain-control circuits, and ac meter response.

Tone-Burst Generation

A tone burst can be generated by a pulse generator, a sinusoidal signal source, and a switch or gate, which, on command from the pulse generator, either passes or blocks the passage of signal from the source. The switching device may be a relay, a motor-driven contactor, a photoresistor-light source combination, a transistor, or a diode bridge. Such a combination generally requires some design and fabrication of components by the assembler and may often be less than satisfactory in convenience, reliability, size, cost, and performance. Performance requirements, in particular, are sometimes more demanding than can be satisfied by a simple timing system, especially in regard to coherence.

Coherence

A coherent tone-burst signal is one in which each burst starts at the same point in the signal being gated or switched, and each burst ends at the same point in the signal cycle. For example, each tone burst might start at the positive-slope zero crossing of the sinusoidal signal, continue for two full

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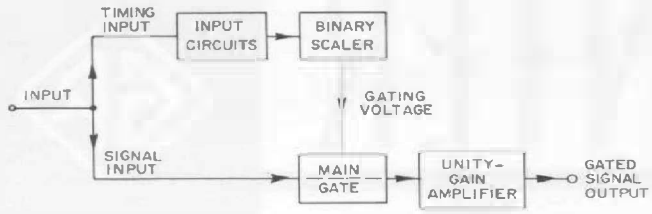

Figure 1. Elementary block diagram of the Type 1396-A Tone-Burst Generator.

cycles, and end at a positive-slope zero crossing. It is obvious that the spacing between bursts must be an exact whole number of signal periods (cycles) in order to maintain coherence. This leads to the conclusion that, to be coherent, a tone burst must be produced from a single autonomous signal. A switch actuated by two independent timers (one controlling the on time, and the other the off time) cannot in practice produce a coherent burst, since the on and off times must be exact multiples of one period of the gated signal, which is a nearly impossible stability requirement. To produce a coherent burst, the gating signals must be locked to the desired subharmonics of the gated signal.

The influence of coherence on performance is demonstrated by analysis of the frequency components in a tone burst, which consist of the fundamental and harmonics of the repetition rate of the tone burst. The expression for amplitude of these harmonics is given in the appendix, below. As an example, Figures 8 and 9 show the amplitude of the first thirty-one harmonics of tone bursts of one cycle on, one cycle off, and of eight cycles on and eight cycles off, respectively. The figures show the spectra for two gating phases of each tone burst. In one case switching occurs at zero crossings, and in the other case switching is at the peak value of the signal. The spectrum varies smoothly between the limits shown as a function of gating phase. The examples indicate clearly that the frequency content of a tone burst depends upon the number of cycles in the burst, the spacing between bursts, and upon the gating phase of the burst. The effects of phase are significant for shorter bursts at short spacings. Therefore, to produce a tone burst with defined characteristics, tight control of phase as well as cycle content is necessary.

For example, consider the case of a burst of exactly eight cycles width, but of uncontrolled phase. The result is that each pulse has constant energy, but the way in which this energy is distributed in the frequency spectrum is not controlled. Unless the tone burst is used in an extremely wide-band system the observed system responses will be inaccurate and not reproducible.

THE TONE-BURST GENERATOR

The Type 1396-A Tone-Burst Generator provides an instrumentation bridge for the gap between continuous-wave testing and step-function, or pulse, testing. A digital method of controlling gating action allows the production of signals that easily meet the requirements of tight control of frequency content and phase. Figure 1 is a block

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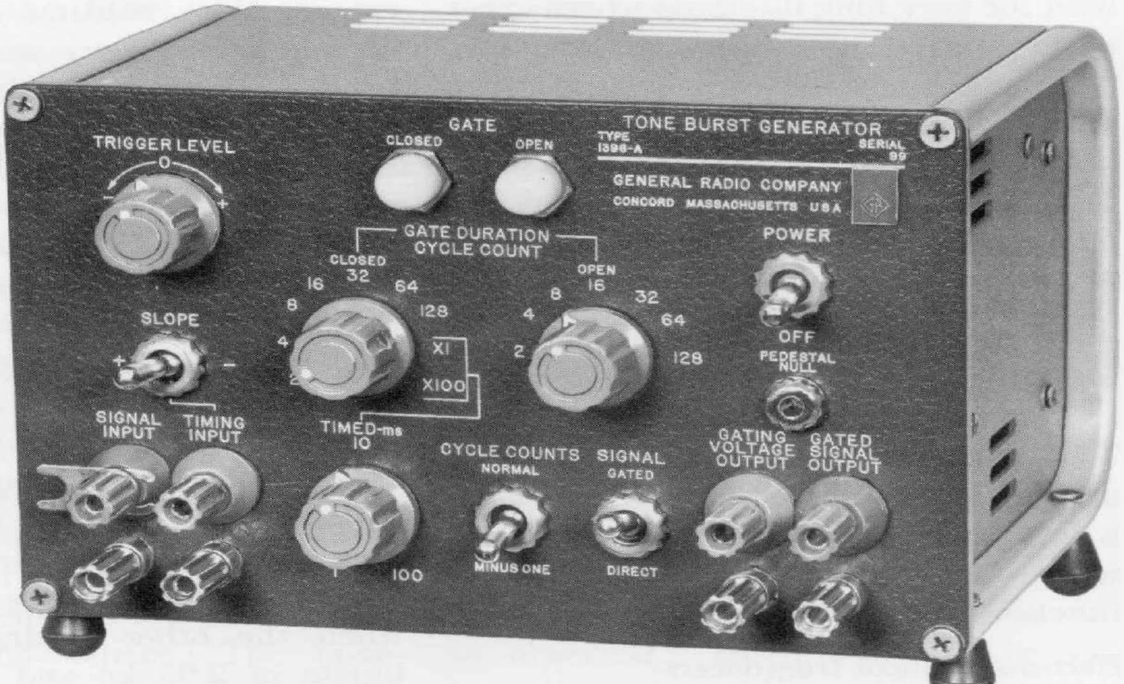


Figure 2. View of the Type 1396-A Tone-Burst Generator.

diagram. Instead of using the common system of timers to establish the off and on times, with a complex locking system to maintain a coherent output, this instrument uses a binary scaler to establish the number of cycles in the burst and between bursts and a simple trigger system to control the phasing. The binary scaler essentially divides the input frequency to the desired subharmonic frequency for gating. A simple reset system allows the same scaler chain to be used for both off and on intervals. The use of binary circuits has resulted in an economical, rugged, and compact instrument, which is quite simple to operate, drift free, and requires no routine maintenance.

The settings of the controls (Figure 2) determine the number of cycles for which the gate will be open and, independently, the number of cycles for which the gate will be closed. The choice offered here by the binary scaler is 2, 4, 8, 16, 32, 64, or 128 cycles. Another control allows the scalers to be started at one instead of zero, which changes the choice of cycle counts to 1, 3, 7, 15, 31, 63, or 127. The scalers then control a simple transistor gate, which operates on the externally applied periodic input signal to produce tone bursts.

Additional features of the Tone-Burst Generator are a switch that holds the gate open for preliminary alignment of external equipment (if necessary); trigger controls, which allow complete control of the phase of the gate and input signal; the ability to use separate input signals for the gate timing and gated signals; and a timed mode for extremely long periods between bursts. In the timed mode, the closed gate interval is set by a one-millisecond-to-ten-second timer, and an internal gate system maintains coherence of gated and gating signal. The timer circuit operates as a locked oscillator and is used for very long intervals where exact cycle count is not required for accuracy. Although sinusoidal input signals are assumed in most of the applications listed below, the instrument will function on any periodic waveforms. If pulses are applied to the TYPE 1396-A, it performs as a word generator, or frequency divider.

APPLICATIONS

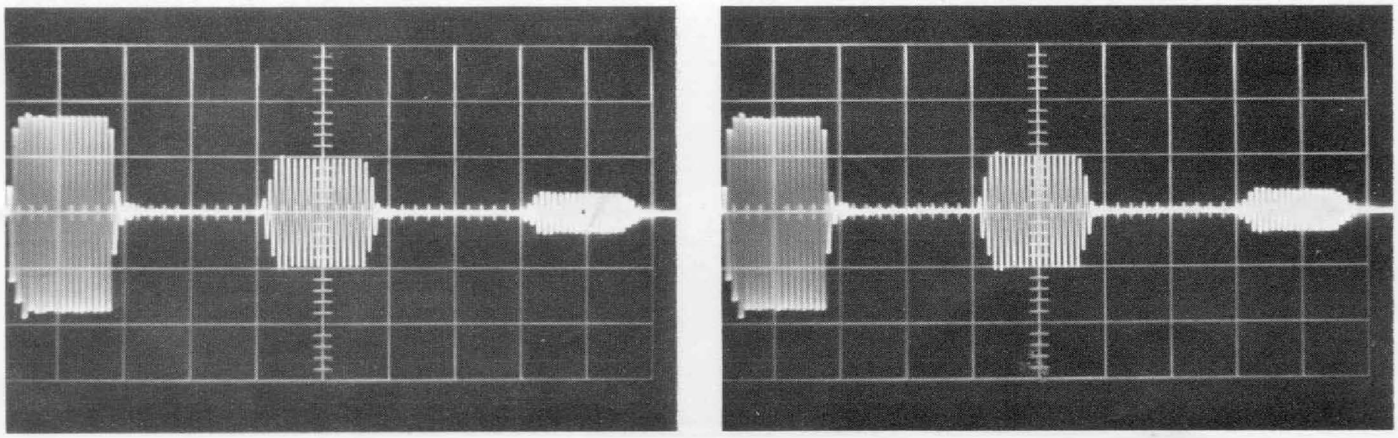
The wide range of applications of the TYPE 1396-A Tone-Burst Generator is due to the nature of tone-burst signals, which span the two fields of continuous-wave testing and of pulse or step-function testing.

Electro-Acoustical Transducers

One common application for tone bursts is the testing of transducers in an ambient not free of echoes. The tone-burst test techniques can be used to separate direct and reflected signals and to eliminate standing-wave effects. Examples of this are the testing of sonar transducers in a tank that produces reflections and of speakers or microphones in a chamber that produces echoes. With continuous-wave testing, errors in frequency and phase curves can result from the addition of reflected signals to the direct response. Such errors introduce familiar standing-wave patterns in the response curves.

With a tone-burst test signal energizing the transducer, one can separate the direct response and the reflected response by observing the response as a function of time. As an example, two one-inch-diameter speakers were mounted in one end of an eight-foot tube with the opposite end closed. Figures 3a and 3b are the voltage waveforms observed across one speaker when the other is driven with tone bursts of 2.95 kc and 3.0 kc, respectively. Note the large pulse at the left, which is the direct transmission from one speaker to the other. Its constant amplitude indicates that the frequency response is the same at both frequencies. The middle and right-hand pulses are the first and second reflections from the far end of the tube.

Figures 4a and 4b are the voltage waveforms observed across the same



Figures 3a (*left*) and 3b (*right*). Waveforms received by one of two transducers mounted in the end of a closed tube, when the other transducer is driven by a tone burst of (a) 2.95 kc. and (b) 3.0 kc. From left to right, the pulses are the direct response, the first reflection from the tube end, and the second reflection from the tube end. Notice the consistency in amplitude of the direct pulse at the two frequencies; compare with Figures 4a and 4b.

speaker when the other was driven, again, with a signal of 2.95 kc and 3.0 kc, but with the gate of the Tone-Burst Generator held open to produce continuous waves. Note that the reflection phenomena now cause large differences (3:1) in the response of the system at the two frequencies. It would be difficult to determine the true speaker response from the continuous-wave data.

Self-Reciprocity Transducer Calibration

A transducer can be calibrated in terms of its response to its own echo when the transducer to be tested and a rigid reflecting surface are placed in an otherwise anechoic space.[1] The Tone-Burst Generator is a convenient source of excitation signal for such a system.

Sonar transducers have been calibrated by a self-reciprocity system with tone-burst excitation of a bridge containing the transducer as the unknown.[2] From two impedance measurements it is possible to calibrate the transducer. A further advantage of tone-burst excitation for the bridge is that high peak power can be applied without danger of exceeding the dissipation limits of the bridge arms.

Amplifier Testing

Tone-burst signals are nearly ideal waveforms for tests of amplifier performance. In sonar circuitry they are used to measure amplifier pulse-envelope distortion, and rise and fall times.

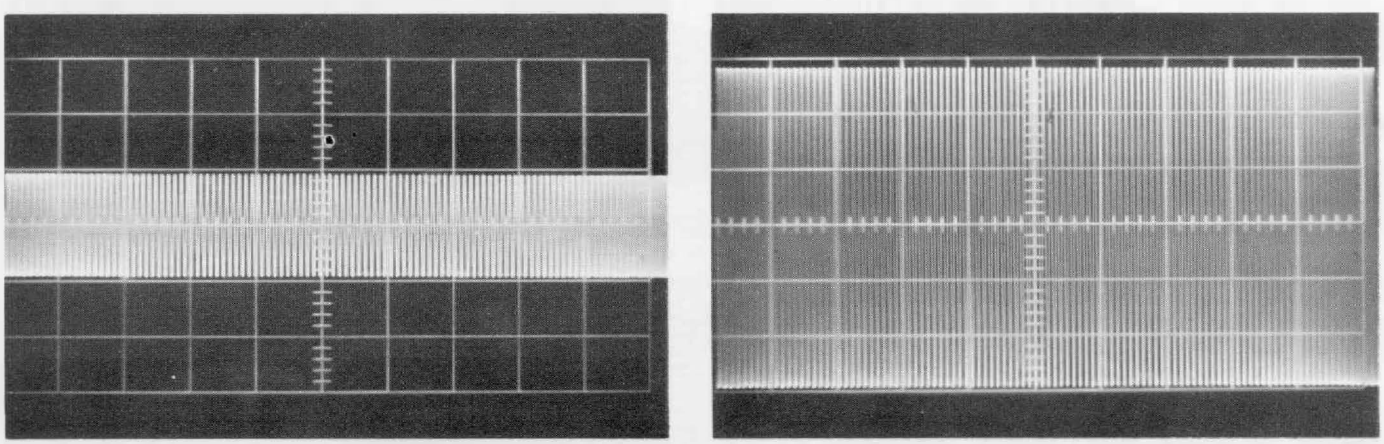
Music Power Tests

Peak-power tests of amplifiers may use tone-burst signals to avoid overloads on the power supplies, with consequent shift in bias points, and also to avoid excessive power dissipation. Music power (peak) output tests of power amplifiers for consumer use require a brief tone burst to be applied and its amplitude increased until 5% distortion is observed.[3] Distortion can be detected by observation of the amplifier output waveform if the distortion level is sharply defined. When an accurate distortion measurement is desired, a dual-channel or differential-input oscilloscope can be used, and the amplifier input subtracted from the output to leave only the distortion products.

[1] Leo L. Beranek, *Acoustics*, McGraw Hill, 1954, pg 382 ff.

[2] Gerald A. Sabin, "Transducer Calibration by Impedance Measurements," *Journal of the Acoustical Society of America*, Vol 28, No. 4, pp 705-710, July 1956.

[3] *EIA Standard, RS-234-A*, November 1963, "Power Output Ratings of Packaged Audio Equipment for Home Use." Electronic Industries Association, 11 West 42nd Street, New York 36, New York ($ .25).



Figures 4a (*left*) and 4b (*right*). Waveforms produced in the same manner as those in Figure 3, except that the driving signal is a continuous one of (a) 2.95 kc. and (b) 3.0 kc. The variation of amplitude indicates the presence of standing waves, which obscure the transducer's frequency characteristic.

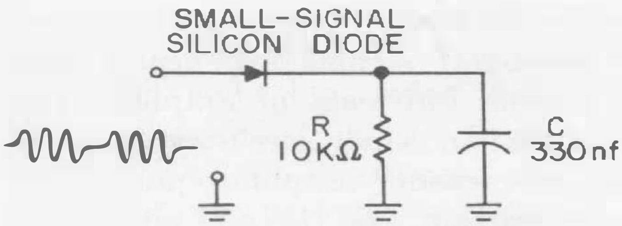


Figure 5a. Example of a simple rectifying circuit tested with a tone burst.

Measurement of Room Acoustics

The reflections produced in a concert hall are determining factors in the acoustical quality of the space. In a test system, a sound source, which may be a pistol shot or a speaker system, is on the stage. A microphone, placed in the seating area, drives the necessary analyzing equipment. Comparisons of pistol-shot and continuous-wave excitation of a hall have shown significant differences in determining reverberation time, a cardinal acoustical property.[4] Such differences indicate that the duration of the exciting signal is important, and, therefore, that a tone burst of controlled properties is desirable.

An excellent discussion of the response of four concert halls (La Grande Salle, Montreal; Clowes Hall, Indianapolis; Symphony Hall, Boston; and Philharmonic Hall, New York City) to tone-burst tests is given by Schultz and Watters.[5]

Testing of Low-Speed Digital Equipment

The TYPE 1396-A Tone-Burst Generator can operate on any periodic waveform. If square or rectangular waveforms are applied to the instrument, it can generate pulse words at a bit rate determined by the gate settings. Such words are useful in testing digital equipment. For testing binary devices the MINUS ONE setting of the CYCLE COUNTS switch is useful, since it permits testing with words containing an odd number of bits.

Filter Testing

The response of a bandpass filter to a suddenly applied signal in its pass band is a common measurement.

This type of signal cannot be simulated by the usual cw generator, and ordinary pulse waveforms will produce ringing, which is difficult to analyze. With the Tone-Burst Generator, the envelope of the transient can be observed and measured.

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[4] Theodore J. Schultz, "Problems in the Measurement of Reverberation Time," *Journal of the Audio Engineering Society*, October, 1963.
[5] Theodore J. Schultz and B. G. Watters, "Propagation of Sound Across Audience Seating," *Journal of the Acoustical Society of America*, Vol 36 No. 5, May, 1964.

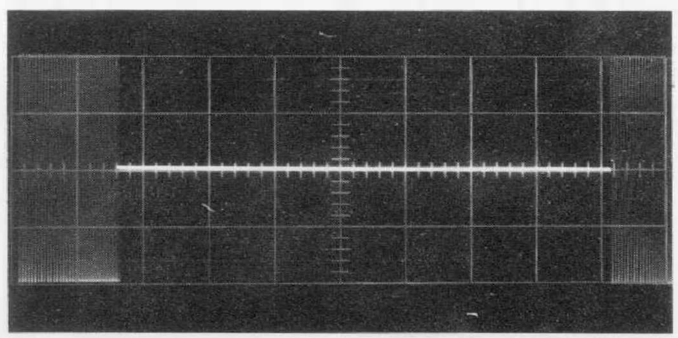


Figure 5b (*above*). Open-circuit voltage waveform of Tone-Burst Generator output (32 cycles of 10-kc signal per burst). Scales are 2 volts per major division vertically and 2 msec per major division horizontally.

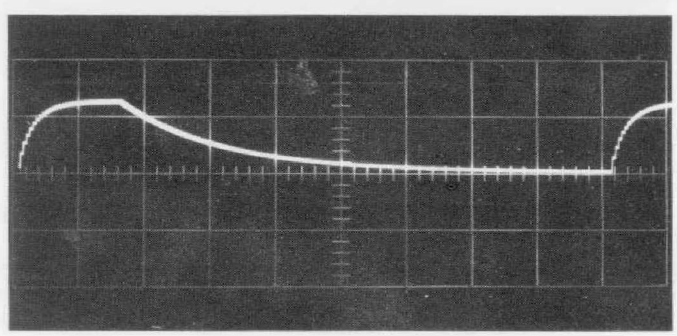
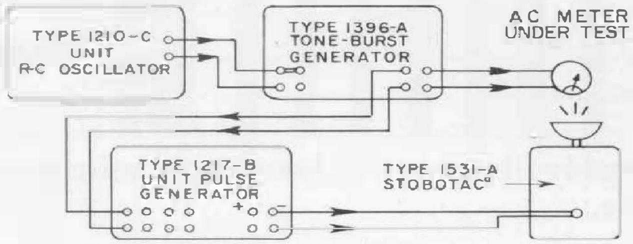
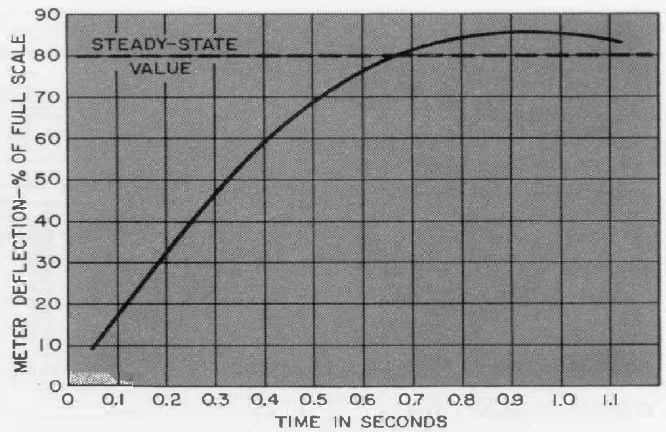


Figure 5c (*right*). Waveform of capacitor voltage when the voltage waveform of Figure 5b is applied to the circuit of Figure 5a. Scales are the same as in Figure 5b.

Figure 6a (*below*). Test system for measuring deflection vs time for an ac meter.

Figure 6b (*right*). Deflection as a function of time for an ac meter excited by a tone burst.





Loudspeaker Distortion Measurements

Distortion measurements can be made with tone-burst excitation of speakers.[6,7] A gated microphone is used to respond to the signal produced by the speaker after the tone burst has been cut off. This "hangover" is a measure of the distortion of the speaker. Such systems are capable of using sweep techniques and being at least semi-automated.

Testing of Rectifying-Type Circuits

Detector and other rectifying circuits lend themselves directly to tone-burst testing. The rectification efficiency and time constants of such circuits can be tested easily with tone-burst excitation. For example, consider the waveforms of Figures 5b and 5c, which were taken from the simple rectifier circuit of Figure 5a.

AC Meter Ballistics

Tone-burst response tests for characteristics such as rise time, fall time, and overshoot, are frequently required for rectifying meters, particularly VU meters. Figure 6a shows a test system for measuring the meter deflection as a function of time.[8] The frequency at which the test is performed must be low enough so that the meter can reach full scale in 128 cycles. The tone bursts consist of 128 cycles of test frequency, and their spacing is adjusted so that the meter returns to rest at zero after each burst. The TYPE 1217-B Unit Pulse Generator acts as a delay circuit. Its negative output pulse starts as the Tone-Burst Generator's gate opens, and the pulse ends at a time determined by the settings of the PULSE DURATION controls. The end of this pulse initiates a microsecond flash of the STROBOTAC® electronic stroboscope. The PULSE DURATION controls set the time between the energizing of the meter and the flashing of the bright-light source. The ambient light should be controlled to permit accurate observation of deflection when the flash occurs, and to allow the scale to be seen between flashes.

Figure 6b is a plot of deflection *vs* time for an ac meter when energized by a burst of 128 cycles of 40-cycle signal. The rise time from 10% to 90% of full scale is 0.5 second, and the overshoot is 6%, which corresponds to a

[6] M. C. Kidd. "Tone-Burst Generator Checks A-F Transients," *Electronics*, Vol 25, No. 7, pp 132–135, July 1952.
[7] M. J. Whittemore, "Transistorized Tone Burst System for Transient Response Testing of Loudspeakers," *Journal of Audio Engineering Society*, Vol 10, No. 3, pp 200–203, July 1962.
[8] This system is patterned after a similar system for dc meters, a description of which appeared in the January-February 1962 issue of the *Experimenter*.

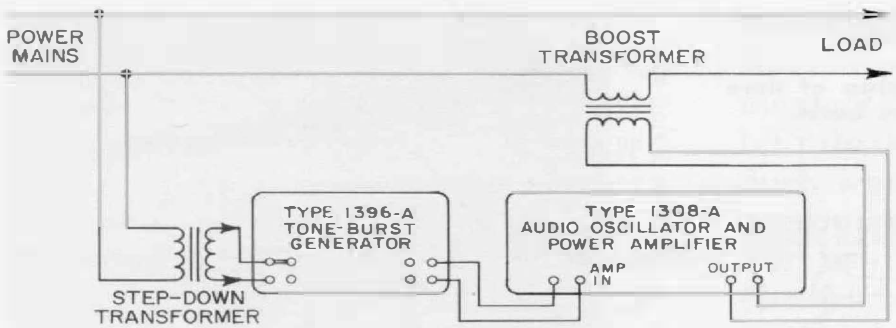


Figure 7. Tone-burst system for generating power-line transients.

meter cutoff frequency of approximately 0.9 cps.

High-Power Transients

Tone-burst testing allows the average signal power to be kept arbitrarily low, although the pulse, or burst, power level may be very high. This low-duty ratio condition may be necessary if the device under test has nonlinearities (i.e., the test properties depend on power level) and if the test equipment cannot operate continuously at the desired signal or power levels.

The General Radio TYPE 1308-A Audio Oscillator and Power Amplifier can be combined with the TYPE 1396-A Tone-Burst Generator to produce audio-frequency tone bursts whose power content may be as high as 200 watts. The Tone-Burst Generator can be used to drive the power amplifier portion of the TYPE 1308-A. For higher frequencies, the TYPE 1233-A Power Amplifier, which delivers up to 15 watts, can be used.

Generation of Line Transients

A method of producing controlled transients in a power-line signal is shown in Figure 7. The step-down transformer isolates the instruments from line voltage and drops the voltage to the proper range for operation of the instruments (one-half volt, rms). The boost transformer may be omitted if the total load current is less than 5 amperes rms.

Others

In addition to those briefly outlined above, the Tone-Burst Generator has many applications. As a calibrated source of ac transients, it is invaluable in evaluating the characteristics of audio and supersonic devices.

— J. K. SKILLING

APPENDIX

Frequency Content of Tone Bursts

Some applications may require a knowledge of the frequency components of the tone burst. For a sinusoidal signal, the burst voltage can be expressed as a Fourier series having only sine or cosine terms as follows:

$$e(t) = \sum_{n=1}^{\infty} a_n \begin{Bmatrix} \sin \\ \cos \end{Bmatrix} \left[\frac{2\pi n t}{(N+M)\,T} \right]$$

$e(t)$ = the tone-burst voltage.
a_n = the amplitude of the nth component.
n = harmonic number (1, 2, 3, 4, etc.).
N = number of cycles of signal in the burst (OPEN count in the Tone-Burst Generator).
M = number of cycles (periods) of signal between bursts (CLOSED count in the Tone-Burst Generator).
T = the period of the signal being gated.

The sine series is used if the signal is gated on and off at zero crossings, and the cosine series if gating is at the peak point of the sinusoidal input voltage. The equation indicates that a tone burst is equivalent to a signal of amplitude a_1 at the repetition rate of the tone burst, plus a signal of amplitude a_2 at twice the repetition rate (the second harmonic), plus a signal of amplitude a_3 at three times the repetition fre-

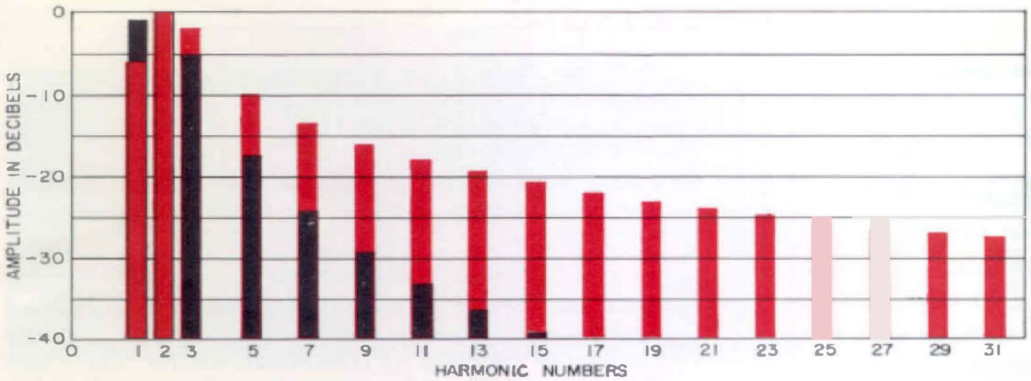


Figure 8. Amplitude of the first 31 Fourier harmonics of a one-cycle-on, one-cycle-off tone burst. Switching at zero crossings in black; switching at peak points in red.

quency (the third harmonic), and so on, indefinitely. The amplitude of each component in the above series is given by:

$$a_n = E\frac{N}{N+M}\left[\frac{\sin x}{x} \mp \frac{\sin y}{y}\right]$$

where:

$$x = 2N\left(\frac{n}{N+M} - 1\right)\frac{\pi}{2}$$

$$y = 2N\left(\frac{n}{N+M} + 1\right)\frac{\pi}{2}$$

E = the amplitude of the signal being gated.

The values of N and M are on the Tone-Burst generator controls. When x or y equals zero, the two fractions involved assume indeterminate forms, but the proper value of the fraction under these conditions is one.

As an example of the use of these equations, consider a tone-burst signal having one cycle on and one cycle off (M = N = 1). The amplitude equation is:

$$a_n = E\left[\frac{\sin (n-2)\frac{\pi}{2}}{(n-2)\frac{\pi}{2}} \mp \frac{\sin (n+2)\frac{\pi}{2}}{(n+2)\frac{\pi}{2}}\right]$$

The two fractions in the bracketed expression are subtracted if the input signal is gated at zero crossings and added if gating is at the peak. The table below gives the amplitudes for values of n equal to 1, 2, 3, 4, and 5 with both zero crossings and peak-point gating:

n	*Zero-crossing gating*	*Peak-point gating*
1	0.424 E	0.212 E
2	0.500 E	0.500 E
3	0.255 E	0.382 E
4	0	0
5	0.061 E	0.152 E

Figure 8 is a plot of the first thirty-one harmonics of the above signal. Figure 9 shows, as a second example, the first thirty-one harmonics of an eight-cycle-on, eight-cycle-off tone burst. The two curves were taken from an automatic plot of the frequency spectrum produced by using a General Radio Type 1900-A Wave Analyzer and Type 1521 Graphic Level Recorder. In the two examples the tone burst had N = M, for which case the amplitudes are zero for even values of n (except zero). Therefore, when a tone burst is "square", i.e., has equal on and off time, there are no even harmonics except the one that may be at the input-signal frequency.

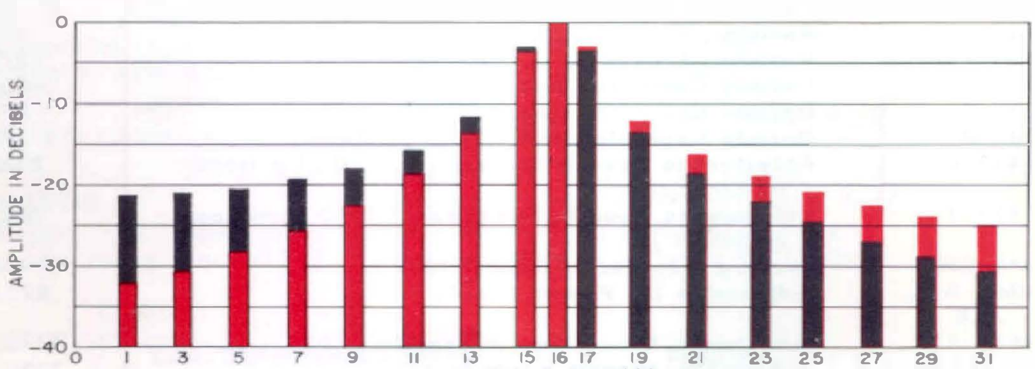


Figure 9. Amplitude of the first 31 Fourier harmonics of an 8-cycle-on, 8-cycle-off tone burst. Switching at zero crossings in black; switching at peak points in red.

SPECIFICATIONS

SIGNAL INPUT (signal to be gated)

Frequency Range: dc to 500 kc.

Maximum Voltage Level: ±7 volts (5 volts, rms).

Input Impedance: Approximately 10 kilohms.

TIMING SIGNAL (signal that controls gate timing)

Frequency Range: dc to 500 kc.

Maximum Voltage Level: ±10 volts.

Minimum Voltage Level: 1 volt, peak-to-peak.

Input Impedance: Approximately 7 kilohms.

Triggering: Slope selectable, trigger level adjustable from −7 to +7 volts.

GATE TIMING: Gate-open and -closed intervals can be independently set to 2, 4, 8, 16, 32, 64, or 128 cycles (periods) of timing signal. By means of a MINUS ONE switch, intervals can be set to 1, 3, 7, 15, 31, 63, or 127 cycles. The gate-closed intervals can also be timed in increments of one period of timing signal from 1 msec to 10 sec. Fixed timing errors are less than 0.5 μsec.

GATED SIGNAL OUTPUT

Gate-Open Output: Maximum signal level is ±7 volts. Total distortion is less than −60 db (compared to maximum level) at 1 kc and 10 kc.

Gate-Closed Output: Less than 140 millivolts, peak-to-peak, (−40 db) with maximum signal input.

Pedestal Output (dc potential difference between open- and closed-gate output): Can be nulled from front panel. Less than 50-millivolt change with line voltage.

Switching Transients: Less than 140 millivolts, peak-to-peak, (−40 db compared to maximum signal input).

Output Impedance: 600 ohms.

GATING VOLTAGE OUTPUT (signal for triggering oscilloscope): Rectangular waveform of approximately + 12 volts at 10-kilohm source when the gate is closed and approximately −12 volts at 20 kilohms when the gate is open.

GENERAL

Ambient Operating Temperature: 0 to 50 C (32 to 122 F).

Power Requirements: 105 to 125 (or 200 to 240, or 210 to 250) volts, 50 to 60 cps, 15 watts, approximately.

Accessories Supplied: TYPE CAP-22 Power Cord.

Accessories Required: External source for any desired frequency range between 0 and 500 kc.

Cabinet: Bench type with rubber feet. Front feet are extendible to tilt cabinet.

Dimensions: Width 8, height 5⅞, depth 7½ inches (205 by 150 by 195 mm), over-all.

Net Weight: 6½ pounds (3 kg).

Shipping Weight: 10 pounds (4.6 kg).

Type		*Price*
1396-A	**Tone-Burst Generator**	**$490.00**

PRICE CHANGES

Economies recently achieved in manufacture have made possible substantial price reductions in certain models of our TYPE 500 Resistors, TYPE 980 Decade Capacitor Units, and TYPE 1419 Polystyrene Decade Capacitors.

Increased material costs have necessitated price increases in a few items.

Type		*Old Price*	*New Price*
500-V	**Resistor,** 200,000 ohms	$ 8.50	**$ 7.50**
500-W	**Resistor,** 500,000 ohms	17.00	**11.00**
500-X	**Resistor,** 1 megohm	27.00	**16.00**
980-B	**Decade Capacitor Unit,** 0.01-μf steps	51. ~~56.00~~	**45.00**
980-C	**Decade Capacitor Unit,** 0.001-μf steps	57.00	**45.00**
980-D	**Decade Capacitor Unit,** 0.0001-μf steps	57.00	**50.00**
1419-A	**Polystyrene Decade Capacitor,** 1.110 μf in steps of 0.001 μf	205.00	**180.00**
1419-B	**Polystyrene Decade Capacitor,** 1.1110 μf in steps of 0.0001 μf	262.00	**230.00**
874-QNP	**Locking Adapter to Type N Jack**	5.00	**5.50**
1265-AM, -AR	**Adjustable DC Power Supply**	875.00	**1050.00**
1630-AL	**Inductance-Measuring Assembly**	2440.00	**2660.00**
1630-AV	**Inductance-Measuring Assembly**	3230.00	**3450.00**

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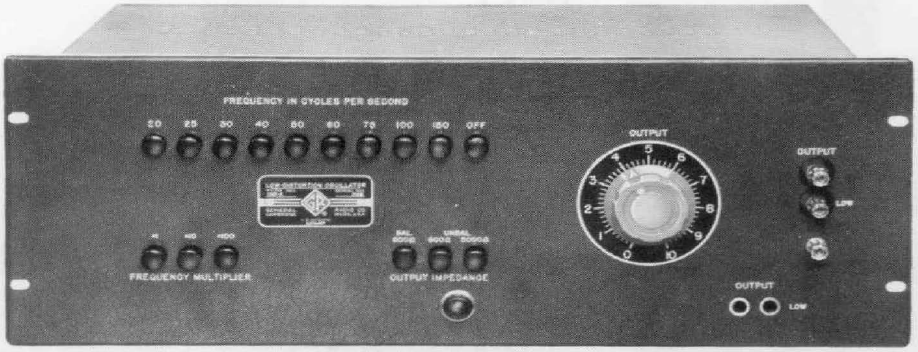

LOW-DISTORTION OSCILLATOR

We have received a number of inquiries for the TYPE 1301-A Low-Distortion Oscillator, and we are glad to announce that this instrument is still available from stock.

The Low-Distortion Oscillator provides push-button selection of 27 fixed frequencies between 20 and 15,000 cps. These are the recommended test frequencies for audio distortion measurements in radio-broadcasting stations.

This oscillator and the TYPE 1932-A Distortion and Noise Meter comprise a system for the fast and accurate measurement of distortion and noise level in audio-frequency circuits.

SPECIFICATIONS

FREQUENCY

Control: A frequency of 20, 25, 30, 40, 50, 60, 75, 100, or 150 cps is selected by a push button. Push-button multipliers of 1, 10, and 100 are provided.

Accuracy: $\pm(1\frac{1}{2}\% + 0.1$ cps).

Stability: Frequency changes with line voltage or output load are negligible. Drift is not greater than 0.02% per hour after the first 10 minutes.

OUTPUT

Impedance: Selected by push button; 600 ohms, balanced; 600 or 5000 ohms, grounded.

With balanced load, 600-ohm balanced output is balanced for all audio frequencies. The 5000-ohm output varies with potentiometer setting between 1000 and 6000 ohms. Potentiometer also has slight effect on 600-ohm grounded impedance.

Voltage (Max): 30 volts, open circuit; 6.6 volts with 600-ohm load constant with frequency within ±1 db.

Power: 18 milliwatts into 600 ohms; 100 milliwatts into 5000 ohms.

DISTORTION AND NOISE LEVEL

Distortion: 5000-ohm output, not more than 0.1%; 600-ohm output, not more than 0.1% between 50 and 7500 cps, and not more than 0.25% below 50 cps.

AC Hum: Not more than 0.05% of output voltage.

GENERAL

Terminals: Jack-top binding posts with standard ¾-inch spacing, a ground terminal, and a standard Western Electric double output jack on the front panel; duplicate output terminals on the rear of the instrument.

Power Input: 105 to 125 (or 210 to 250) volts, 25 to 60 cps, 45 watts. Specify line voltage and frequency when ordering.

Operation from 400-cycle supply is possible if line voltage is between 110 and 125 volts; power-frequency hum is increased at 200- and 400-cycle output.

Accessories Supplied: TYPE CAP-22 Power Cord, multipoint connector, TYPE 1301-201 Plug Assembly, spare fuses.

Mounting: Relay-rack panel. End frames are available for table mounting. (See price table below.)

Panel Finish: Standard General Radio gray crackle.

Dimensions: Width 19, height 7, depth 13½ inches (475 by 180 by 345 mm), over-all.

Net Weight: 31½ pounds (14.5 kg).

Shipping Weight: 35 pounds (16 kg).

Type		*Price*
1301-A	Low-Distortion Oscillator	$595.00
FRI-412-2	Aluminum End Frames	15.00 pair

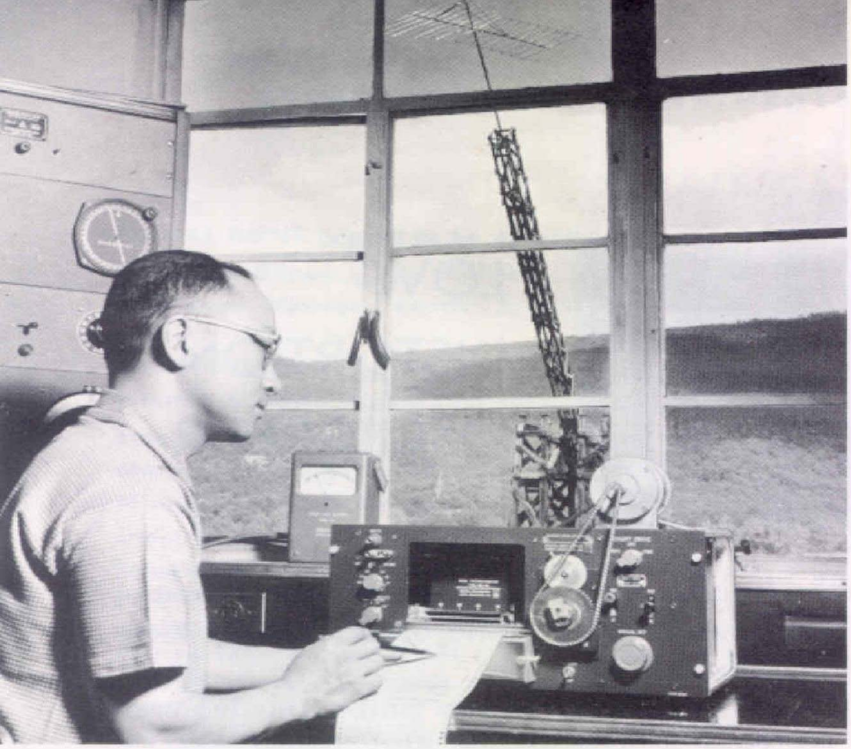

Figure 1.

AUTOMATIC PLOTTING OF ANTENNA PATTERNS

The TYPE 1521-A Graphic Level Recorder is shown here (Figure 1) at Channel Master Corporation plotting automatically the directivity pattern of a Super-Crossfire antenna. A Selsyn transmitter is mounted on the shaft of the motor that rotates the antenna. The Selsyn receiver drives the recorder through a chain and spur gear (to do this, the gear shift on the recorder must be in neutral, as shown). By choice of gear ratio, the chart can be calibrated in the desired number of degrees per division. A 40-db range on the vertical scale is ordinarily used. The receiving antenna is not visible in the photograph. The driving oscillator, which can be partially seen just over the shoulder of the operator, is a General Radio Unit Oscillator, with the TYPE 1263 Amplitude-Regulating Power Supply to ensure constant excitation level. Figure 2 shows a typical record plotted on this equipment for the Channel Master #3607 Super-Crossfire antenna of Figure 3.

Figure 2 (*below*). Typical antenna pattern at 83.25 Mc.

Figure 3 (*right*). View of the antenna with inset showing detail of one element.