VOL. 14, NO.

Electronic Design 27

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

NOVEMBER 29, 1966

SIGNAL GENERATORS

—oscillators, squarewave, pulse, sweep and noise generators—over 1500 are on the market.

Next time you need one, check this special reference issue first. Comprehensive specs, prices and technical articles will make you a more informed buyer and user.

1966

Signal Generator Reference Issue

David H. Surgan New Products Editor

This directory is valuable. Use it properly, and you can make an intelligent, comparative instrument selection from the 1500 signal sources currently available.

Tables of specifications, including prices, have been supplied by the Technical Information Corp., P. O. Box 514, Smithtown, N. Y. They are up-to-date, complete and specific. Check them before you buy.

In addition, there are four technical articles, written by engineers at Tektronix, General Radio, Polarad and Marconi. They will help you "read between the lines" and develop an applications-oriented point of view.

To make the best use of the directory, follow this easy procedure:
- Compare the specs and get a feeling for performance/cost ratios.
- Bring your literature file up-to-date by using the Master Cross Index on page 4
- Follow the selection-application guidelines offered in the articles.

How to Use the Tables

The tables in this directory have been arranged for simple and rapid reference. Each table covers a particular type of signal generator, and lists pertinent technical specifications for instruments of that type. Unless otherwise specified in the tables, the following condition applies to all the instruments listed:

- Input voltage: 105-125 Vac, 60 Hz, 1 phase

Prices indicated in the tables are subject to change by the manufacturer.

An index of manufacturers and models is included at the end of each table. These indexes are alphabetical, by manufacturer, and list the various instruments of each manufacturer. A location key is included after each model in the index. This permits easy spotting in the table of the specifications for that instrument, by means of the location-key column (first column) in the table.

How the tables are arranged

Within the tables, instrument specifications are given in separate, appropriately headed columns. The complete specifications for any one instrument can thus be read across the page.

For each table the instruments are listed in ascending order of upper frequency limit. To facilitate table use, the columns containing this parameter are tinted. In cases where the upper frequency limit of several units is the same, the instruments are listed in increasing order of frequency swing.

Manufacturers are identified in the Mfr. column by an abbreviation. The complete name of each manufacturer can be found in the index at the end of the section. For manufacturers' addresses and Reader Service literature offerings, see the master index, which starts on page 4.

All notes and symbols used in a table are defined at the end of that table.
At the top of each page of a table the frequency range covered by the instruments listed on that page is specified. This is to expedite the location of a unit having a particular frequency output.

To use the tables effectively

1. **Note how the instruments are listed.**
   They are in ascending order of upper frequency limit. Where this is the same, they are in order of increasing frequency swing.
2. **Select the most likely candidates.**
3. **Obtain supplementary data from the manufacturer.**
   Manufacturers' addresses, together with Reader-Service numbers for specific types of signal generators, are given in the master cross index.

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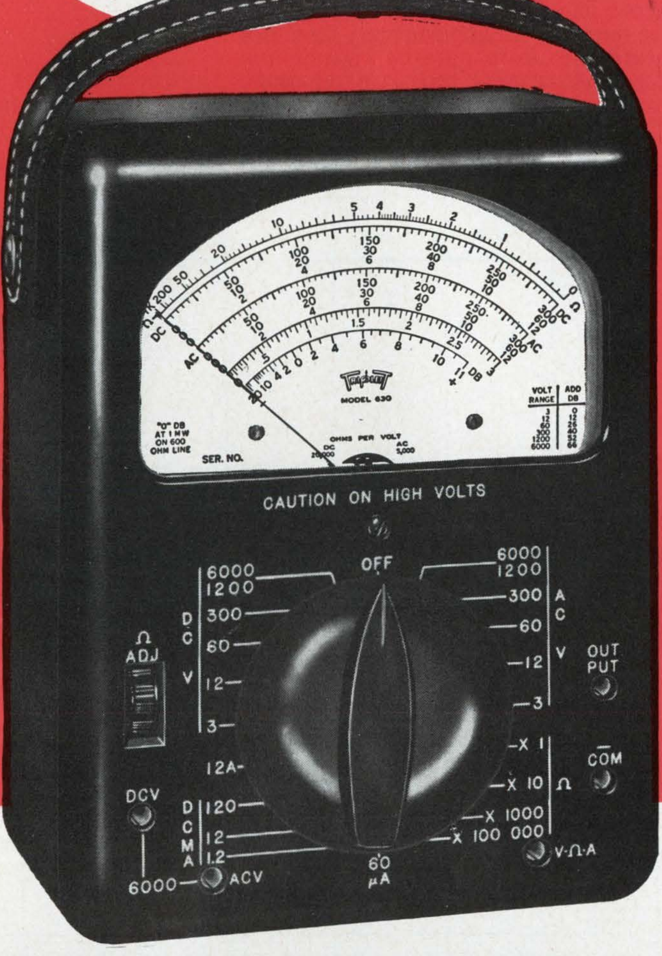
Standard Of The Industry



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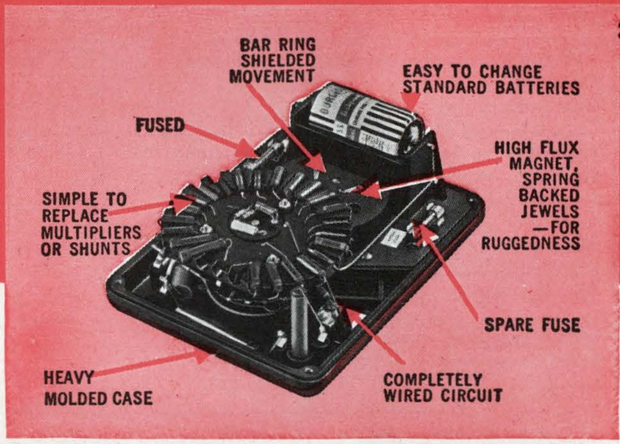

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MEGOHMS	0-1-100.
DC MICRO-AMPERES	0-60 at 250 millivolts.
DC MILLI-AMPERES	0-1.2-12-120 at 250 millivolts.
DC AMPERES	0-12.

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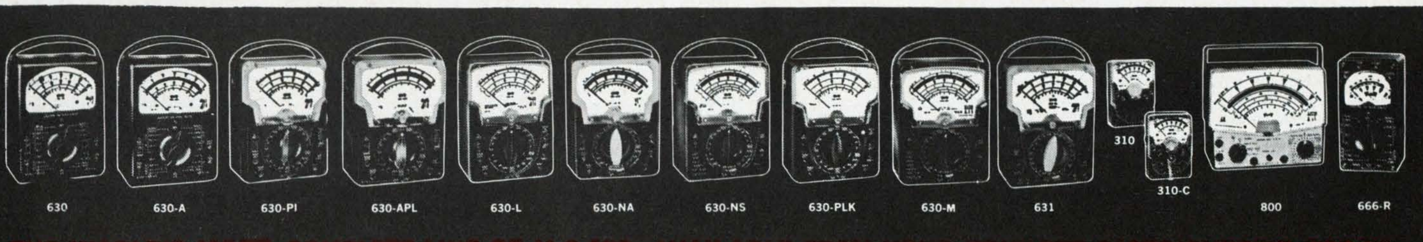

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Master Cross Index

Manufacturers of the product types listed in this issue are indicated either by stars or by Reader Service numbers (if supplementary literature is available). Bring your literature file up to date by circling the appropriate numbers on the Reader Service card at the back of the issue.

Manufacturer								
Address	Abbreviation	Oscillator	Signal	Noise	Pulse	Sweep	Squarewave	Function
Adar Associates 73 Union Square Somerville, Mass	Adar				★			
Advanced Measurement Instruments Inc 109 Dover St Somerville, Mass	AMI		1			2		
Aerospace Research, Inc 130 Lincoln St Boston, Mass	ARI			3				
Airborne Instrument Laboratory Comac Rd Deer Park, LI, NY	Airborne	4		5				
Aircraft Radio Corp Rockaway Valley Rd Boonton, NJ	Aircraft Radio		★					
Alfred Electronics 3176 Porter Drive Palo Alto, Calif	Alfred				6	7	8	
Allison Laboratories, Inc 11301 Ocean Ave La Hambra, Calif	Allison			9				
American Electronic Labs, Inc P.O. Box 552 Lansdale, Pa	AEL				★			
Anadex Instruments, Inc 7833 Haskell Ave Van Nuys, Calif	Anadex						10	
Antlab, Inc 6330 Proprietors Rd Worthington, Ohio	Antlab						★	
Applied Microwave Laboratory 106 Albion St Wakefield, Mass	App Microwave	11						
Arenburg Ultrasonic Lab, Inc 94 Green St Jamaica Plain, Mass	Arenburg	12						
Argonaut Associates, Inc P.O. Box 273 Beaverton, Ore	Argonaut							13
B & K Instruments, Inc 5111 W. 164th St Cleveland, Ohio	B & K	★		★				
Babcock Electronics Corp 3501 Harbor Blvd Costa Mesa, Calif	Babcock		14					
Barker & Williamson, Inc Canal St & Beaver Dam Rd Bristol, Pa	B & W	15						

Manufacturer								
Address	Abbreviation	Oscillator	Signal	Noise	Pulse	Sweep	Squarewave	Function
Beckman Instruments, Inc Computer Operations 2200 Wright Ave Richmond, Calif	Beckman			★				
Berkeley Nucleonics Beckman Instruments, Inc 1429 Oregon Street Berkeley, Calif	Berkeley				★			
Blonder-Tongue Labs, Inc 9 Alling St Newark, NJ	Blonder Tongue					★		
Canoga Electronic Products 1805 Colorado Ave Santa Monica, Calif	Canoga							★
Century Electronics & Instruments 6540 E. Apache Tulsa, Okla	Century	16					17	
Chesapeake Instrument Corp Shadyside, Md	Chesapeake				18			
Clough-Brengle Co 6014 Broadway Chicago, Ill	Clough- Brengle	19	20			21		
Datapulse, Inc 509 Hindry Ave Inglewood, Calif	Datapulse				22			
De Mornay-Bonardi Corp 1313 N. Lincoln Ave Pasadena, Calif	D-B			23				
Digital Electronics Ames Court, Engineers Hill Plainview, NY	Digital Elect				24			
Dymec Division Hewlett-Packard Co 395 Page Mill Rd Palo Alto, Calif	Dymec		25					
Dynatronics P.O. Box 2566 Orlando, Fla	Dynatronics		26					
E-H Research Laboratories, Inc 163 Adeline St Oakland, Calif	E-H				27	28		
ENSCO, Inc 3100 Eldridge St Salt Lake City, Utah	ENSCO				33		34	
EPSCO, Inc 411 Providence Highway Westwood, Mass	EPSCO		★			★		
Electro Design, Inc 8141 Engineer Rd San Diego, Calif	Electro Design				★			
Electronic Instrument Co, Inc 131-01 39th Ave Flushing, NY	EICO	29	30			31	32	
Electronic Measurements Corp 625 Broadway New York, NY	EMC		★					

Manufacturer								
Address	Abbreviation	Oscillator	Signal	Noise	Pulse	Sweep	Squarewave	Function
Elgenco, Inc 1550 Euclid St Santa Monica, Calif	Elgenco			35				
Empire Products Singer Metrics Division 915 Pembroke St Bridgeport, Conn	Empire			36				
Exact Electronics, Inc 455 S.E. Second Ave Hillsboro, Ore	Exact							37
Fairchild Instrumentation 750 Bloomfield Ave Clifton, NJ	Fairchild				38		39	
Frequency Engineering Lab P.O. Box 527 Farmingdale, NJ	FEL	40						
General Applied Science Labs Merrick & Stewart Aves Westbury, NY	GASL				★			
General Electric Co 40 Federal St West Lynn, Mass	GE					★		
General Microwave Corp 155 Marine St Farmingdale, NY	Gen Micro			41				
General Radio Co 22 Baker St Concord, Mass	Gen Radio	42	43	44	45	46	47	
Gertsch Products Singer-Metrics Div 3211 La Cienega Blvd Los Angeles, Calif	Gertsch		48					
Grundig 150 Nassau St New York, NY	Grundig	★	★			★		
Hallicrafters Co 4401 W. 5th Ave Chicago, Ill	Hallicrafters	★						
Hathaway Instruments, Inc 5250 E. Evans Ave Denver, Colo	Hathaway	158						
Heath Co Hilltop Rd Benton Harbor, Mich	Heath	49	50			51	52	
Hewlett-Packard Co 1501 Page Mill Rd Palo Alto, Calif	H-P	53	54	55	56	57	58	59
Hickok Electrical Instrument Co 10514 Dupont Ave Cleveland, Ohio	Hickok		60			61	62	
Holt Instrument Labs P.O. Box 230 Oconto, Wis	Holt	63						

Manufacturer								
Address	Abbreviation	Oscillator	Signal	Noise	Pulse	Sweep	Squarewave	Function
Houston Omnigraphic Corp 4950 Terminal Ave Bellaire, Texas	Houston							64
Huggins Laboratories, Inc 999 E. Argues Ave Sunnyvale, Calif	Huggins				65			
ITT Industrial Products Division 15151 Bledsoe St San Fernando, Calif	ITT	★		★		★		
Industrial Components, Inc 1675 S.E. Allen Ave Beaverton, Ore	Ind Comp						66	
Industrial Test Equipment Co 20 Beechwood Ave Port Washington, NY	Ind Test Equip	67						
Intercontinental Instruments, Inc 500 Nuber Ave Mount Vernon, NY	Interconti- nental				68			
International Electronic Research Corp 135 Magnolia Blvd Burbank, Calif	IERC	★						
Jerrold Electronics Corp 15th & Lehigh Philadelphia, Pa	Jerrold	★				★		
Kay Electric Co Maple Ave Pine Brook, NJ	Kay	69	70	71	72	73		
Krohn-Hite Corp 580 Massachusetts Ave Cambridge, Mass	Krohn-Hite	74					75	76
Kruse-Storke Electronics 790 Hemmeter Lane Mountain View, Calif	Kruse- Storke	155				156		
LTV Ling Electronics Div Ling-Temco-Vought 1515 S. Manchester Ave Anaheim, Calif	LTV Ling					77		
Laboratory For Electronics, Inc 1075 Commonwealth Ave Boston, Mass	LFE	78				79		
MSI Electronics, Inc 116-06 Myrtle Ave Richmond Hill, NY	MSI					★		
Marconi Instruments 111 Cedar Lane Englewood, NJ	Marconi	80	81	82		83	84	
Measurements P.O. Box 180 Boonton, NJ	Measurements	85	86		88			
Microdot, Inc 220 Pasadena Ave S. Pasadena, Calif	Microdot	89	90					
Micro-Power, Inc 25-14 Broadway Long Island City, NY	Micro-Power					91		

Manufacturer								
Address	Abbreviation	Oscillator	Signal	Noise	Pulse	Sweep	Squarewave	Function
Monsanto Electronics Department 800 N. Lindbergh Blvd St. Louis, Missouri	Monsanto				92			
Motorola Comm & Elect, Inc 4501 W. Augusta Rd Chicago, Ill	Motorola		93					
Muirhead Instruments, Inc 111 Bristol Rd Mountainside, NJ	Muirhead	94						
Narda Microwave Corp Commercial St Plainview, NY	Narda	95				96		
Navigation Computer Corp Valley Forge Indl Park Norristown, Pa	Nav Comp	97						
Northeast Electronics Corp Airport Rd Concord, NH	Northeast			★				
Optimation, Inc 7243 Atoll Ave N. Hollywood, Calif	Optimation	98						
PRD Electronics, Inc 1200 Prospect Ave Westbury, NY	PRD	99		100				
Piezo Technology 2400 Diversified Way Orlando, Fla	Piezo		★					
Polarad Electronic Instruments 34-02 Queens Blvd Long Island City, NY	Polarad	101	102	103	104	105		
Precise Electronics & Development Corp 76 E. 2nd St Mineola, NY	Precise		106				107	
Precision Apparatus Co, Inc 80-00 Cooper Ave Glendale, NY	Prec Apparatus	108				109	110	
Probescope Co 211 Robbins Lane Syosset, NY	Probescope	★				★		
RCA, Electronic Components & Devices 415 S. 5th St Harrison, NJ	RCA	112	113			114	115	
RFD, Inc 1501 W. Cass St Tampa, Fla	RFD	★						
RS Electronics Corp 795 Kifer Rd Sunnyvale, Calif	RS		★					
Radar Engineers 4719 Brooklyn Ave N.E. Seattle, Wash	Radar Engr				116			
Radiometer Electronics The London Co 811 Sharon Drive Westlake, Ohio	Radiometer	117	118					

Manufacturer								
Address	Abbreviation	Oscillator	Signal	Noise	Pulse	Sweep	Squarewave	Function
Rohde & Schwarz Sales Co, Inc 111 Lexington Ave Passaic, NJ	R & S	119	120	121		122		
Rutherford Electronics Co 8944 Lindblade St Culver City, Calif	Rutherford				★			
Schlumberger c/o E.F. Associates 100 Quimby St Westfield, NJ	Schlumberger	★						
Scientific-Atlanta, Inc P.O. Box 13654 Atlanta, Ga	S-A	123					124	
H. H. Scott 121 Powdermill Rd Maynard, Mass	HH Scott			157				
Servo Corp of America 111 New South Rd Hicksville, NY	Servo				★	★		★
Siemens America, Inc 350 Fifth Ave New York, NY	Siemens	125						
Sierra Electronic Div Philco Corp 3885 Bohannon Dr Menlo Park, Calif	Sierra	126	127					
Signalite, Inc 1933 Heck Ave Neptune, NJ	Signalite			128				
Smyth Research Assoc 3555 Aero Court San Diego, Calif	Smyth		129					
Spectral Dynamics Corp 8159 Engineers Rd San Diego, Calif	Spectral Dynamics					130		
Spencer-Kennedy Labs, Inc 1360 Soldiers Field Rd Boston 35, Mass	S-K				★			
Stewart Bros Division Instrument Laboratories Corp 315 W. Walton Place Chicago, Ill	Stewart	131						
Stoddart Electro Systems Div Tamar Electronics 2045 W. Rosecrans Ave Gardena, Calif	Stoddard			132				
Strand Laboratories, Inc 143 Main St Cambridge, Mass	Strand	133						
Technical Materiel Corp 700 Fenimore Rd Mamaroneck, NY	Tech Materiel	153						
Tektronix, Inc P.O. Box 500 Beaverton, Ore	Tektronix	134			135		136	
Tel-Instrument Electronics Corp 728 Garden St Carlstadt, NJ	Tel-Inst		137			138		

Manufacturer Address	Abbreviation	Oscillator	Signal	Noise	Pulse	Sweep	Squarewave	Function
Telonic Industries, Inc 60 N. First Ave Beech Grove, Ind	Telonic					139		
Texas Instruments, Inc 3609 Buffalo Speedway Houston, Texas	Texas Inst				140			
Texscan Corp 51 S. Koweba Lane Indianapolis, Ind	Texscan					141		
Triplett Electrical Instruments 286 Harmon Rd Bluffton, Ohio	Triplett		142					
Velonex Instrument Div Pulse Engineering, Inc 560 Robert Ave Santa Clara, Calif	Velonex				111			
Walkirt 10321 S. La Cienega Blvd Los Angeles, Calif	Walkirt				★			
Wang Laboratories, Inc 836 North St Tewksbury, Mass	Wang				143			
Waveforms, Inc 333 6th Ave New York, NY	Waveforms	144				145		
Waveline, Inc P.O. Box 718 W. Caldwell, NJ	Waveline			146				
Wavetek, Inc 8133 Engineer Rd San Diego, Calif	Wavetek							154
Wayne-Kerr Corp 18-22 Frink St Montclair, NJ	Wayne-Kerr	★						
Weinschel Engineering Co, Inc P.O. Box 577 Gaithersburg, Md	Weinschel	147			148	149	150	
Weston, Boonshaft & Fuchs Hatboro Industrial Park Hatboro, Pa	Weston	151						
Wiltron Co 930 Meadow Drive Palo Alto, Calif	Wiltron					152		


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Buying a pulse generator?

These systematic guidelines will take the guesswork out of selecting.

As a prospective buyer of a pulse generator, you are confronted by more than 100 different models, some of which emphasize some features at the expense of others. If you want the best pulse generator and the best set of trade-offs for your dollar, use a systematic approach to selection. Three basic elements are involved:

- Specifying the characteristics the job calls for.
- Selecting a generator with these characteristics.
- Worst-case testing of a loan instrument.

But before you can begin specifying the pulse generator, you must know your applications.

Performance, cost and function must be balanced

At times all that is required is a repetitive trigger with a few adjustable characteristics. A low-cost pulser may fill the bill here. When the pulse generator is needed as a general signal source for circuit development, cleanliness of waveshape may be the most important attribute. However, features such as variable dc baseline offset, variable rise and fall times, and pretrigger output might all be considered. For use in triggering multivibrators, pulse shape is not important within wide limits, but period may well be. In the calibration of other instruments, accuracy and cleanliness may both be important. For repetitive testing requiring more than one type of pulse, one might consider a pulse generator with programing. Programing can eliminate the need for two or more pulse generators, by permitting quick selection of various types of preadjusted pulses. In general, variable rise and fall times make it possible to test circuits more nearly under actual operating conditions, or to check response to trigger variations. This feature is becoming more generally available.

Other features that are useful in some applications include trigger input, delayed pulse, double pulse, pulse bursts, simultaneous positive and negative polarity pulses and calibrated controls. Some generators have a control calibrated for period, which may be a more convenient reading than repetition rate. Period is easily related to pulse width and may be determined directly from an oscilloscope. Repetition rate is more conveniently related to a frequency counter.

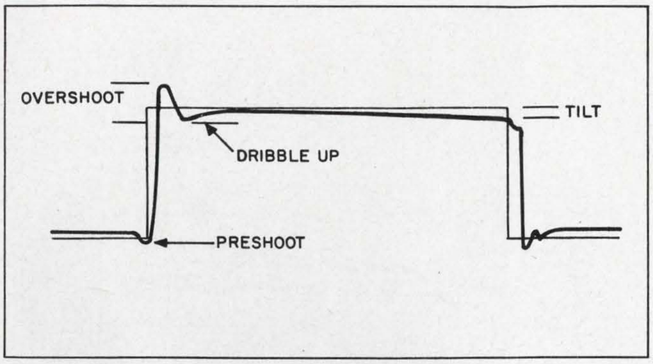
When buying one particular feature, be aware of the other specs that may suffer. For example, before specifying more amplitude than required, consider which trade-offs accompany high voltage *and* fast rise time in the same instrument. These generators are usually high-power units meant for driving 50-Ω loads. An instrument with a clean 50-V output will often produce a very degraded pulse at lower amplitude. It may be impossible to get a clean low-voltage pulse even with an attenuator. Clean, high-frequency, 50-Ω attenuators are simply not available at power ratings of greater than 2 to 5 W. This means that even moderate duty cycles from a 50-V generator cannot be attenuated cleanly for lower voltage applications. However, you can easily attenuate a 10-V pulse at high duty cycles with the low-power attenuators.

A look beyond the spec sheet is necessary

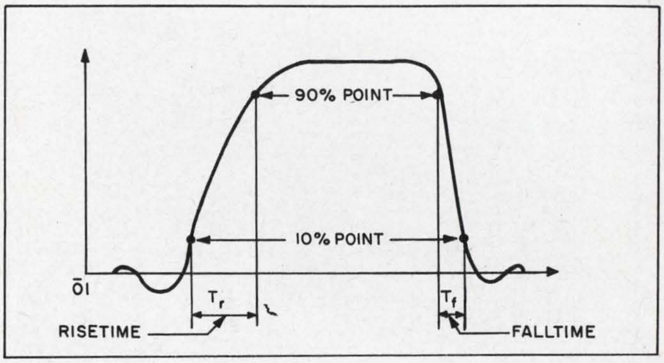
Some specifications of pulse-generator characteristics are straightforward and easy to understand. Other specifications are often incomplete or misleading, and, in some instances, some characteristics are not even mentioned. Two categories cover most of the parameters that define the pulse output: (1) The range of adjustment, and (2) How the pulse deviates from ideal.

Adjustment ranges: This category may include maximum and minimum limits in adjusting pulse amplitude, pulse width, pulse period (or repetition rate) and rise time, fall time, or delay time. Expect a specification in this category to be straightforward, but not always—for example, maximum pulse amplitude. A spec that states 10-V peak *from* a 50-Ω source might imply a 5-V pulse when the

Jerrold Rogers & William Stevens, Instrument Engineers, Tektronix, Inc., Beaverton, Ore.



1. **Waveform distortions** do exist, no matter how ideally the pulse is specified.



2. **Rise and fall times** are measured at 90% and 10% points.

output is terminated in 50 Ω. Specifying the amplitude *into* a 50-Ω load, and also specifying the open-circuit amplitude, is clearer. At times the spec sheet may be clear enough, but the buyer may not stop to relate one spec to another. For example, if a certain period (or repetition rate) is required, it is important to check whether a maximum duty cycle limitation of the pulse generator will limit operation to too short a pulse width.

Waveform: No matter how ideally the pulse output is specified, distortions do exist (Fig. 1). They include:

- Preshoot—the initial excursion of the waveform which precedes the leading or trailing edge. It may be of the same or opposite polarity.
- Rise time—the interval between the instances at which the instantaneous pulse amplitude first reaches specified lower and upper limit. Unless otherwise stated, these limits are 10% and 90% of the pulse's amplitude. Fall time is analogously defined (Fig. 2). Although not distortions, rise and fall times are limitations to be considered in specifying.
- Overshoot—the initial excursion beyond the limiting final value. It occurs simultaneously with the leading or trailing edge.
- Rounding—the lack of a sharp corner of a waveform, or a smooth transition from leading or trailing edge to the limiting final value.
- Ringing—periodic bumps in the waveform that occur after the overshoot. When specified, it may be peak-to-peak, flat top-to-peak or rms. The latter two produce smaller numbers but not less ringing.
- Tilt—an up or down slope to the otherwise flat top, also called top slope or, more commonly, droop. Other flat-top aberrations do exist, but usually they are not specified or even mentioned individually. They are sometimes called "other aberrations" and ideally should be expressed as a percentage of flat-top amplitude. Sometimes they are collected into a single aberrations spec and included with overshoot, ringing and tilt. One such "other aberration" could be called "dribble up." This is a gradual creep up to the flat-top amplitude, too slow to be considered rounding. On shorter pulse widths it will look like tilt or up slope, while on very long widths it will look like a rounded corner.
- Dc baseline shift—the change in the dc level of the baseline.
- Baseline aberrations—almost never mentioned. They are spurious signals or noise on the baseline and, if large enough, may cause false triggering or other complications.
- Jitter in pulse period, in pulse width and between a trigger and a pulse output—the time uncertainty of these quantities, usually expressed as a percentage of the time interval.

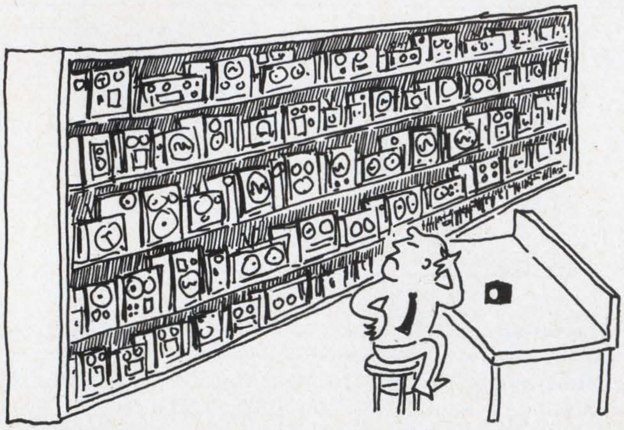
These waveform anomalies are often unclearly specified or not mentioned. When something is not specified, it may have been overlooked or been deemed not important enough to clutter up the spec sheet. On the other hand, it may be too costly to spec, or even too embarrassing to mention.

Sometimes a waveform photograph will be displayed in place of, or in addition to, some of the specifications. However, you can be fairly certain that a worst-case setup was not made for the photograph. When something is specified as "negligible" or even given as a vague percentage, it may just as well have been omitted.

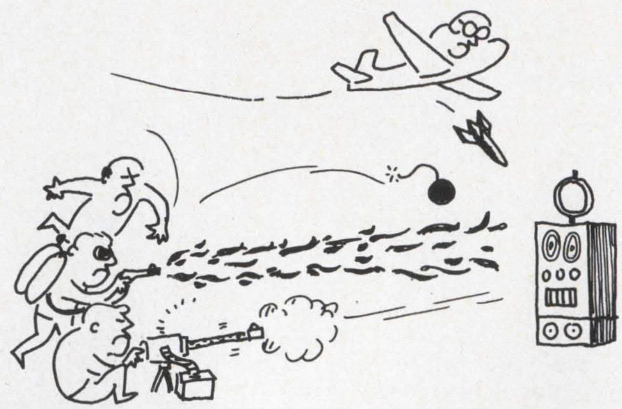
The only sure way to determine the cleanliness of waveform is to test the pulse generator. In deciding what generators to evaluate, consider future needs and the possibility of including some additional flexibility. Considerations other than cost should be kept in mind.

Put the pulser through its paces

Testing a pulse generator in your own laboratory is the surest way to determine whether it meets your needs. Examine the construction techniques and estimate maintainability. Look for components that seem to be running excessively hot, as they may signal possible early failure or a reliability problem. The controls of the instrument should



Hundreds of pulsers do hundreds of jobs. Balance performance, cost and function with your application.



Worst-case testing will turn up waveform aberrations and provide a critical look at the manufacturer's specs.

be easily interpreted and easy to adjust to the desired waveform. An overlap of ranges is helpful, as is a reasonably linear continuous control. If the control is too nonlinear, there may be too much change in adjustment in some very small knob rotation.

When obtaining an evaluation instrument, check whether there are ways in which it may be unintentionally damaged. For example, the output transistor can often be destroyed by an inductive load, and unless there is built-in protection, a generator may be damaged by shorting the output. A front panel adjustment can wreck some generators by allowing for too high a duty factor at high amplitude. Study the instruction manual, and list those precautions that must be observed for each of the generators being tested.

The most difficult parameters to verify will be the ones involving waveform aberrations. Difficulties arise because of a lack of industry standards in nomeclature, and, in the case of some very clean pulse generators, aberrations in the measuring oscilloscope itself. Know the type and magnitude of aberrations in the scope, so that meaningful results can be obtained.

Zero in on choice with worst-case tests

Quick verification of the manufacturer's specifications with the use of a scope, clean 50-Ω cables, terminating resistors and attenuators pads should be followed by setting up worst-case conditions for a more critical look. Here, additional care must be taken in choosing the hardware for testing. Mismatched load, cables and connectors can destroy a clean pulse. The following procedure will turn up waveform aberrations under worst-case conditions:

1. Look at the longest-duration (maximum-width) pulse at maximum amplitude and low-duty cycle. Check for tilt, usually caused by poor design of ac-coupled circuits, and for dribble-up, often caused by thermal time constants. Note any low-frequency (1- to 10-μs period) ringing, usually caused by poor decoupling of the power supply feeding high-current switches.

2. Increase the repetition rate to give a 90% duty cycle (or the generator's specified duty cycle limit). Under some conditions, this limit may be exceeded, but be sure the specifications clearly state that no damage will occur. Check for a baseline shift from the low-duty-cycle dc level. Thermal dribble-up may decrease, since the junction temperature is more constant (constantly higher) at high-duty cycles. Over-all behavior can become erratic due to increased power supply loading for marginally designed power supplies. Finally, watch carefully for any pulse amplitude reduction. Specification of this condition is often circumvented by specification of a maximum-duty-cycle limitation on the instrument. Some generators have no duty cycle limitation, and when pulse width exceeds the selected period, the pulse generator usually counts down (period doubles). The transition interval from normal operation to countdown may be a clean change in mode, or the waveform may become unstable at this point. (Be careful with higher power generators at high duty cycle into low-power terminating resistors or attenuators. Unfortunately most clean attenuators are low-power (1/2 to 2 watts). Clean, high-power attenuators are as rare as ideal pulses).

3. At maximum-duty cyle, check and record the faster aberrations and characteristics at appropriately higher sweep speeds. Record such things as rise time, overshoot and ringing at both leading and trailing edges.

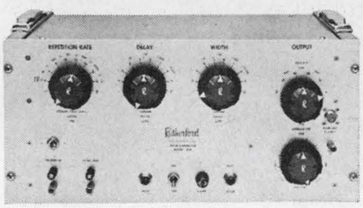
4. Reduce the amplitude. Most generators are far cleaner at maximum amplitude. Thus, at a lower amplitude, check carefully for aberrations of the pulse when it is reduced by the variable amplitude controls or by the internal passive attenuators, which are usually switched controls. Also note any baseline shift due to amplitude variation. ■ ■

Rutherford DIVISION
CMC

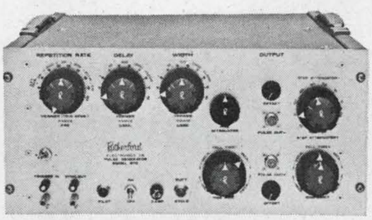
PULSE & TIME DELAY GENERATORS

RUTHERFORD HIGH VOLTAGE PULSE GENERATORS ARE THE STANDARD OF THE INDUSTRY

The B-7 series of vacuum tube pulse generators have earned a reputation for high performance, precision and reliability. They have the accuracy and versatility to meet today's rigid standards of testing, research and development. They have proven their capabilities as systems components as well as in field operation.



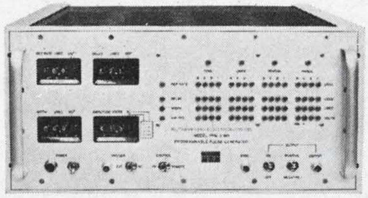
Model B-7B features rep rates to 2 MHz and outputs of 50 volts into 50 ohms. Printed circuit boards. Variable rise time control. Trouble-free single unit construction. Overload protection. Stabilized noise-free repetition rate schedule. Rack mountable.



Model B-7D incorporates all of the time-proven specifications of the popular Model B-7B with several extra features. Simultaneous positive and negative output pulses are available at front panel connectors. The rise and fall time of each pulse is separate and independent, and may be degraded without affecting the other. The DC level of each output may be set to zero by front panel control, or may be offset.

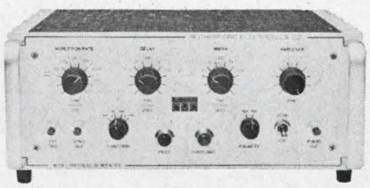
Model B-7F adds the following features to the basic specs of Model B-7B: (1) repetition rate is continuously variable from 2 Hz to 2 MHz; (2) output pulse rise or fall time may be independently degraded to approx. 1 μsec; (3) either single or double pulse output available by front panel control.

NEW—REMOTELY PROGRAMMABLE PULSE GENERATOR



Model PPG3 is the only solid-state, digitally controlled programmable pulse generator of its type. No other automatic pulse generator offers the degree of accuracy, stability, reliability, or range of easy operation. It exceeds requirements of today's most sophisticated automatic checkout systems. All major parameters may be programmed, sequentially or in parallel, with digital information from tape or card readers. Remotely programs to control six to eight information bits. Internal rep rate is .2 μsec – 999 sec in 8 ranges. Pulse delay of 0 to 999 sec. Pulse width at 50% amplitude points is 0.1 μsec – 999 sec. Pulse amplitude is 0-25 volt. Rise and fall time ≤20 nsec.

SOLID-STATE PULSE GENERATORS



Model B-14 is a low cost, highly versatile, compact and portable general purpose pulse generator. It features repetition rate of 20 Hz to 2 MHz. Delay is 0 to 10,000 μsec. Amplitude is 15v into 1,000 ohms, 8v into 50 ohms. Pulse width of .06 to 10,000 μsec. Rise and fall time is less than 10 nanosec, fixed. Rechargeable battery pack available for completely portable operation.

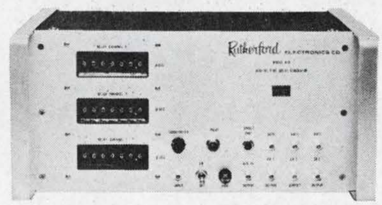
Model B-15 has the same fast rise and fall time, delay and pulse width as Model B-14. In addition, B-15 offers a repetition rate of 5 Hz to 5 MHz. Also, its amplitude is 10v into 50 ohms. Both units are only 12" wide x 5" high x 11½" deep. Rechargeable battery pack available.

Model B-16 all transistorized pulse generator offers a rep rate of 20 Hz - 20 MHz. Variable rise and fall times of less than 5 nsec to greater than 200 nsec. Pulse width is 0.015 - 10,000 μsec. Amplitude is 0 to 10 volts, peak. Single or pulse pair operation. Rack mount available.

SOLID STATE DIGITAL TIME DELAY GENERATORS

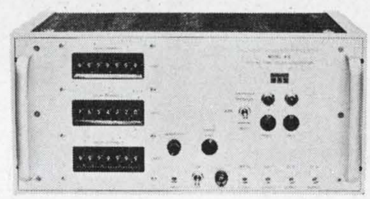
These three time delay generators are designed with solid-state circuitry for reliability and maintenance free performance. Their high accuracy with very low delay jitter lets you calibrate synchroscope sweeps, produce accurately spaced pulses for biological investigations, measure waveform timing, measure pulse width, use with pulse generator for more accurate delay, etc.

All three models below have these specifications: Delay range of 0.0 to 999,999.9 μsec in increments of 100 nsec. Delay accuracy of ±(0.001% of set delay + 2 nsec.) Delay jitter less than 1 nsec.



Model A10 provides 3 delayed pulses. Also offers amplitude of 10 volts, peak, min., into ≥50 ohms. Approx. 15 nanosec rise time. Approx. 50 nsec width. Instrument is 8¾" high x 19" wide x 12" deep.

Model A11 offers single delayed pulse with same basic delayed pulse specs as A10 except amplitude is 6 volts, peak, min., into ≥ 50 ohms. And rise time is approx. 10 nsec. Unit is half-rack size (5¼" high x 9½" wide x 14½" deep). Rack mounting unit is available.



Model A12 produces three delayed pulses, and has same basic delayed pulse specs as A10 except amplitude is 70 volts, peak, min., into ≥ 50 ohms. Width is 3 μsec min. Rise time is approx. 0.1 μsec. Repetitive and manual reset operation. Manual offers fail-safe triggering to protect against loss of information.

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ON READER-SERVICE CARD CIRCLE 164

Pulse generators 60 Hz-5 MHz

For information on how to use these tables, turn to page 2

			FREQUENCY		MAIN PULSE				OUTPUT					
	Manufacturer	Model	Min. Hz	Max. MHz	Width Min. μs	Width Max. ms	Rise ns	Fall ns	Min. Volts	Max. Volts	Imp. ohms	Type	Price $	Notes
PG-1	Huggins	961D	50	60 Hz	.002	20 ns	0.5	0.5	0	2000	51	C	900	c
	S-K	503A	50	120 Hz	.0006	100 ns	0.5	ina	ina	ina	50	C	495	d
	GASL	2303-C	10	260 Hz	ina	ina	0.3	ina	0	±100	5	C	485	c,d
	Tektronix	109	275	700 Hz	.0005	300 ns	0.25	0.3	0	50	50	C	360	d
	Weinschel	PG-1A	20	.002	1	.005	ina	ina	0	-1000	50	R	1250	
	Kay	5070-B	50	.005	0.1	0.1	10	10	0.5	0.5	50	R	875	e
	H-P	212A	50	.005	.07	.01	20	20	0	±50	50	C,R	600	
	Servo	9350	0.2	.005	100	1000	5	5	±7	±10	93	C,R	660	a,b,e
	Digital Elect	1554	.05	.005	80	13 sec	1000	1-15μs	5	15	150	C	130	d,e
	Chesapeake	U-100	50	.007	1	.006	500	ina	ina	ina	100	C	795	
PG-2	Polarad	MP-1A	10	.01[6]	0.2	.002	10	ina	15	15	100	C	2575	c
	Ensco	PG214	10	.01	1	1	100	200	0	50	200	C	1075	b
	Ensco	PG114	10	.01	1	1	100	200	0	50	200	C	375	
	Alfred	5-6826P	10	.01	1	.012	500	500	300	450	ina	R	490	
	Tektronix	160A/162	0	.01	100	10 sec	1000	ina	50	50	1000	R	320	
	H-P	218AR/219A	0	.01	ina	ina	100	ina	50	50	50	R	2125	b
	AEL	155	0.1	.01	10	1000	3000	3	.01	250	ina	C	675	
	H-P	218AR/219B	0	.01	0.2	.005	60	ina	0	50	50	R	2490	b
	H-P	218AR/219C	0	.01	1	10	30	30	0	±15,±90	90,500	R	2375	a
	Berkeley	RP-2	60	.05	ina	ina	note 10	note 10	ina	ina	ina	C	890	
PG-3	Berkeley	RP-1	1	.05	ina	ina	50-500	2-100μs	0.1	2.2	100	C	960	
	Tektronix	160A/161	0	.05	10	100	500	ina	0	±5	1800	R	320	
	Measurements	179	60	0.1	0.5	.06	100	150	-150	±200	250,1000	C	365	d
	Texas Inst	6710	30	0.1	0.1	.001	0.35	30	±8	±12	50	C	1500	a,e
	Tektronix	R293	10,000	0.1	.002	0.25μs	1	1	6	12	ina	R	1000	d
	E-H	131	10	0.1	0.1	0.5	10	10	50	50	50	R	575	c
	GASL	2305-C	10	0.1	.002	0.2 μs	1	1	0	±20	50	C	595	a
	Servo	2140A	10	0.1	0.1	1	20	40	0	±80	93	C	1195	b,d,f,h
	Servo	2120A	10	0.1	0.1	1	20	40	0	±80	93	C	895	d,f,h
	Velonex	570	3	0.1	0.3	0.2	50	70	0	-2000	200	C	5390	
PG-4	Velonex	350	3	0.1	0.1	0.2	50	70	0	-2000	200	C	3990	
	Tektronix	111	0	0.1	.002	.0015	500	1	5	5	50	C	365	d
	H-P	1105A/1106A	0	0.1	3	ina	.02	ina	0.2	ina	50	C	750	
	H-P	213B	0	0.1	2	.002	0.1	ina	0.35	0.35	50	C	215	
	Fairchild	404-B	10	0.25	.05	0.105	15	15	-60	+60	50	C,R	760	d
	Datapulse	100	5	0.5	0.1	100	30	40	1	150	50	C,R	345	a
	Digital Elect	521	5	0.5	0.8	120	50-100	100	0	15	150	C	95	c,d,e
	Wang	5SP	0.5	0.5	0.5	500	ina	ina	0	-12	ina	C	150	
	Tektronix	160A/163	0	0.5	1	10	200	200-500	0	25	500	R	320	
	Digital Elect	522	0	0.5	0.5	1 sec	200	200	0	15	100	C	98	c,d,e
PG-5	Texas Inst	6701	100	1	.005	0.1 μs	1	1	±2	±50	50	C	1695	d,e
	H-P	215A	100	1	0	0.1 μs	1	1	-10	+10	50	C,R	1875	
	H-P	214A	10	1	.05	10	13	13	0.2	100	50	C,R	875	
	E-H	125	10	1	.001	0.1	0.2	0.5	-10	-10	50	C,R	2275	c
	Berkeley	PB-2	1	1	0.3	0.1	.05-2 μs	.06-32μs	.001	10.1	100	C	790	
	GASL	PSG-1	1	1	0.1	0.3μs	100	100	0.2	50	50	C	745	
	Datapulse	103M/P906	0	1	.002	0.2 μs	1	1	±3	±3	50	C,R	1860	
	Gen Radio	1395A	2.5	1.2	0.1	1 sec	note 1	note 1	0	±20	1000	C,R	1992	
	Gen Radio	1398A	2.5	1.2	0.1	1.1 sec	5	5	-60	+60	1000	C,R	535	
	Servo	9450	100	2	100	1	5	5	±7	±10	93	C,R	835	a,b,e
PG-6	Rutherford	B-7B	20	2	.05	10	15	15	0	±50	50	C,R	720	d
	Rutherford	B-7D	20	2	.05	10	15	15	0	±50	50	C,R	1200	a
	Rutherford	B-14	20	2	.06	10	10	10	0	15	10-1000	C,R	385	d,e,g
	Rutherford	B-7F	2	2	.05	10	15	15	0	50	50	C,R	920	b
	Tektronix	114	0	2	0.1	1	10	10	-1	+10	50	C	350	d
	Gen Radio	1217C/1201B	0	2.4	0.1	1 sec	15	15	-40	+40	1000	C	370	
	Datapulse	102	2	3	.05	.01 μs	.10-500	10	0	±50	50	C,R	720	c,d
	E-H	132A	5	3.5	0.1	.01 μs	12-100	ina	-50	+50	50	R	715	
	E-H	130	10	4	0.1	.05μs	10	ina	0	±50	50-200	R	1175	d
	E-H	133A	1	5	0.5	0.3	.01-10μs	.02-10μs	±0.2	±50	50	C,R	2275	c

Notes, abbreviations and manufacturers' index at end of this section.

Pulse generators 5 MHz-200 MHz

			FREQUENCY		MAIN PULSE				OUTPUT					
	Manufacturer	Model	Min. Hz.	Max. MHz	Width Min. µs	Width Max. ms	Rise ns	Fall ns	Min. Volts	Max. Volts	Imp. ohms	Type	Price $	Notes
PG-7	Datapulse	103M/P905	5	5	.05	0.5	20	1000	1	30	50	C,R	1490	d,e
	Rutherford	B-15	5	5	.06	10	10	10	0	10	50	C,R	525	b,d,e,g
	Datapulse	103M/P901	5	5	.05	2	20-300	20-200	-15	+13	50	C,R	1450	d,e
	Datapulse	103M/P902	5	5	2	50	100	100	±1	±15	600	C,R	1350	d,e
	Datapulse	103M/P903	5	5	.05	2	5	5	2.5	5	50	C,R	1150	d,e
	Radar Engr	760	5 MHz	6	20 ms	20	8	8	0	2	5	C	88	g
	Walkirt	SWG-101	3000	10	ina	ina	20-200	20-200	0.5	12	note 7	C	345	
	E-H	138	300	10	.05	1	10	10	7.5	15	50	C,R	990	
	E-H	120D	100	10	.01	0.1 µs	0.85	1	-2	-20	50	C,R	1375	
	Servo	9455	100	10	.025	.001	5	5	±7	±10	93	C,R	975	a,b,e
PG-8	E-H	120E	100	10	.01	0.1 µs	0.85	1	-.07	-20	50	C,R	1675	
	Fairchild	792A	50	10	50	500	8	8	0	10	50	C,R	520	d,e
	Digital Elect	721	50	10	.04	50	20	20	0	10	150	C	220	c,d,e
	E-H	121	10	10	.01	0.25	10	10	10	74	50	R	1675	d
	Datapulse	108	10	10	.02	5	7	7	0.2	50	50	C,R	1480	d,e
	Datapulse	101	10	10	.03	10	5	7	0.5	10	50	C,R	345	a,b,c,e,f
	Datapulse	108L	10	10	.03	.005 µs	12	12.5 µs	0.2	50	50	C,R	1980	b,c,d,e
	H-P	222A	10	10	.03	5	4	4	.05	10	50	C,R	690	
	Monsanto	3000	1	10	1	100	note 8	note 8	0.5	10	50	C,R	request	
	Intercontinental	PG-1	1	10	.03	200	10	10	±15	±15	50	C,R	585	d,e
PG-9	Intercontinental	PU-2	0	10	.03	200	10	10	±15	±15	50	C,R	425	d,e
	Tektronix	R116	0	10	.05	0.55	note 5	note 5	0.4	10	50	R	1550	d
	Datapulse	106A	10	12	.025	5	10 ns-1 ms	10 ns-1ms	.01	±12	50	C,R	950	a,b,c,e
	Texas Inst	6613	15	15	.03	.03 µs	note 2	note 2	0	10	50	C	950	a,c,e
	Intercontinental	PG-2	1	16	.03	200	note 11	note 11	0	±20	50	C,R	925	d
	GASL	PG-10	1 MHz	20	.02	0.3 ns	5	5	note 9	note 9	ina	C	960	
	E-H	123-A	1000	20	.02	10	7	7	0	50	50	C	1775	d
	Rutherford	B-16	20	20	0.15	10	5-200	5-200	0	10	50	C,R	875	d
	Electro Design	PG-20	10	20	.03	10	5	5	0	20	50	C	775	
	Intercontinental	PG-32	0.1	20	.03	1000	10 ns-1s	10 ns-1s	±.01	±20	50,500	C,R	1385	a,b,c,d,e
PG-10	Intercontinental	PG-31	0.1	20	.03	1000	10	10	±.01	±20	50,500	C,R	1225	a,b,c,d,e
	Intercontinental	PG-33	0.1	20	.03	1000	5 ns-1 sec	5 ns-1 sec	±.01	±20	50,500	C,R	1350	a,b,c,d,e
	Texas Inst	6601	60	25	.02	.001	6	6	0	5	93	C	1300	b,e
	Texas Inst	6605	60	25	.03	10	note 3	note 3	0	10	50	C	1450	a,c,e
	Texas Inst	6303	60	25	.02	.001	6	6	0	5	93	C	2280	a,c,e
	Servo	9550	2 MHz	40	.025	.001	5	5	±7	±10	93	C,R	1390	a,b,e
	Datapulse	110A	4	40	.01	5	4.5	6	.01	10	50	C,R	1250	a,b,d,e
	Datapulse	109	4	40	.01	50	5	5	1	10	50	C,R	690	a,b,d,e
	Datapulse	111	4	40	.005	500	2	2	0.15	5	50	C,R	1480	a,b,c,e
	Texas Inst	6650	10	50	.01	10	note 4	note 4	.01	10	50	R	1000	d,e
PG-11	E-H	139B	10	50	.01	10	6 ns-3 ms	6 ns-3 ms	±.03	±10	50	C,R	1275	c
	Gen Radio	1394A	1 MHz	100	.004	99 ns	2	2	0	±4	50	C,R	995	
	Texas Inst	6901	1000	100	.002	2	1	1	.005	5	50	R	1800	c,d,e
	H-P	216A	0	100	.005	25 ns	2.5	2.5	0.4	10	50	C,R	1775	
	E-H	122	1000	200	.002	0.1	1	1	±0.15	±5	50	C,R	2875	c

Pulse generators Late arrivals

PG-12	Adar	SQ-260	1000	10	.05	.01	ina	ina	0	±7	51	C,R	5600	

Notes, abbreviations and manufacturers' index at end of this section.

PULSE GENERATORS

NOTES:

a. Both polarities available simultaneously from separate connectors.
b. This unit is a double-pulse generator. These pulses have the same over-all specifications.
c. Rise and Fall time taken between 10% and 90% points.
d. Either polarity available by means of a switch.
e. Solid state.
f. One or more extra sync pulses are available which occur after the first sync pulse in time.
g. Battery operated.
h. Has extra sync pulse available coincident with leading edge of main pulse.

1. Rise and Fall time variable 100 ns-10 ms
2. Rise and Fall time variable 10 ns-10 ms
3. Rise and Fall time variable 10 ns-3 μs.
4. Rise and Fall time variable 5 ns-5 ms.
5. Rise and Fall time variable 10 ns-110 μs.
6. Five independent pulse channels.
7. The output may be terminated in 43, 50 or 600 ohms.
8. Rise and Fall time variable 100 ns-10 ms.
9. +20 V or -36 V at low duty cycle; +15 V or -24 V at high duty cycle.
10. Rise time variable .05-5 μs; Fall time variable 2-100 μs.
11. Rise and Fall time variable .01-200 μs.

ABBREVIATIONS

C Cabinet.
R Rackmount.
ina Information not available.

Index of Manufacturers and Model Numbers

(keyed to table locator symbols)

108 (PG-8)
108L (PG-8)
109 (PG-10)
110A (PG-10)
111 (PG-10)

Digital Electronics (Digital Elect)

521 (PG-4)
522 (PG-4)
721 (PG-8)
1554 (PG-1)

E-H Research Laboratories, Inc

120D (PG-7)
120E (PG-8)
121 (PG-8)
122 (PG-11)
123-A (PG-9)
125 (PG-5)
130 (PG-6)
131 (PG-3)
132A (PG-6)
133A (PG-6)
138 (PG-7)
139B (PG-11)

Electro Design, Inc

PG-20 (PG-9)

ENSCO, Inc

PG114 (PG-2)
PG214 (PG-2)

Fairchild Instrumentation

404-B (PG-4)
792A (PG-8)

General Applied Science Laboratories (GASL)

2303-C (PG-1)
2305-C (PG-3)
PG-10 (PG-9)
PSG-1 (PG-5)

General Radio Co (Gen Radio)

1217C/1201B (PG-6)
1394A (PG-11)
1395A (PG-5)
1398A (PG-5)

Hewlett-Packard Co (H-P)

212A (PG-1)
213B (PG-4)
214A (PG-5)
215A (PG-5)
216A (PG-11)
218AR/219A (PG-2)
218AR/219B (PG-2)
218AR/219C (PG-2)
222A (PG-8)
1105A/1106A (PG-4)

Huggins Laboratories, Inc

961D (PG-1)

Intercontinental Instruments, Inc

PG-1 (PG-8)
PG-2 (PG-9)
PG-31 (PG-10)
PG-32 (PG-9)
PG-33 (PG-10)
PU-2 (PG-9)

Kay Electric Co

5070-B (PG-1)

Measurements

179 (PG-3)

Monsanto

3000 (PG-8)

Polarad Electronic Instruments

MP-1A (PG-2)

Radar Engineers (Radar Engr)

760 (PG-7)

Rutherford Electronics Co

B-7B (PG-6)
B-7D (PG-6)
B-7F (PG-6)
B-14 (PG-6)
B-15 (PG-7)
B-16 (PG-9)

Servo Corp of America

2120A (PG-3)
2140A (PG-3)
9350 (PG-1)
9450 (PG-5)
9455 (PG-7)
9550 (PG-10)

Spencer-Kennedy Labs, Inc (S-K)

503A (PG-1)

Tektronix, Inc

109 (PG-1)
111 (PG-4)
114 (PG-6)
160A/161 (PG-3)
160A/162 (PG-2)
160A/163 (PG-4)
R116 (PG-9)
R293 (PG-3)

Texas Instruments, Inc (Texas Inst)

6303 (PG-10)
6601 (PG-10)
6605 (PG-10)
6613 (PG-9)
6650 (PG-10)
6701 (PG-5)
6710 (PG-3)
6901 (PG-11)

Velonix Instrument Division

350 (PG-4)
570 (PG-3)

Walkirt

SWG-101 (PG-7)

Wang Laboratories, Inc

5SP (PG-4)

Weinschel Engineering Co, Inc

PG-1A (PG-1)

Manufacturers' addresses and literature offerings in master cross index at front of issue.

What's missing in generator specs?

Here are seven secondary parameters to consider and some pitfalls to avoid when buying.

Until the day when all manufacturers agree on one method of specifying signal generators, the prospective buyer will find it difficult to compare competitive models on a point-by-point basis. He will find it especially frustrating when he looks for complete specifications on secondary parameters, such as harmonic content and stability, which are often either hedged or omitted entirely. Here are some of the more important of these secondary parameters that he should bear in mind.

- **Output level**—an apparently straightforward parameter—must be interpreted carefully. Is the specified level into an open circuit or a load? The user must know this or he cannot be sure of output level. Some signal generators are calibrated in microvolts across a standard termination, some in open-circuit microvolts. Mistaking one for the other can easily lead to a 2-to-1 error in interpreting the output level indication. It should be obvious that a properly matched load cannot be provided unless the value to match it to is known.

- **Harmonics in the output** of the signal generator can be especially troublesome when the signal generator is being used to measure a receiver's ability to reject signals outside its pass band. If the rejection ratio to be measured is on the order of 60 to 100 dB and harmonics are lurking only 30 or 40 dB down in the pass band, the measurement will yield inaccurate results.

- **Stability** statements are often missing and, when they are given, often misleading. Optimum conditions (a constant level, constant frequency, constant load, etc.) may be assumed without a statement to that effect. Also, the phrase "after warm-up" (as in "drift after warm-up") in a stability or drift specification is useless, unless it is accompanied by the warm-up period. Similarly, the terms "short-term stability" and "long-term stability" are meaningless without further qualification; there are no standard definitions of "short term" and "long term."

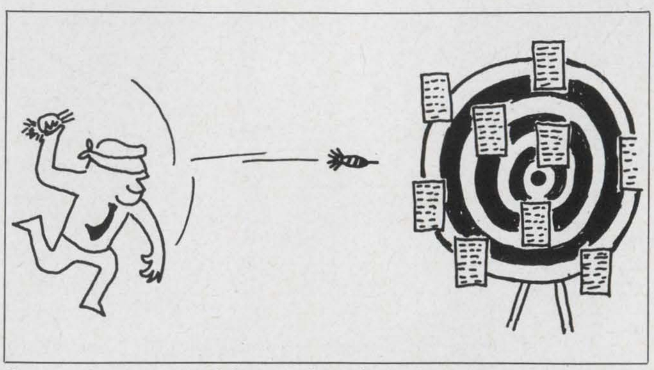
- **Retuning drift**—a rarely stated specification—is the generator's stability when the bandswitch is rotated to another range and returned. The chief problem here is that, when a tank coil is switched into a circuit and starts passing current, it warms up. Switch it out of the circuit and it cools off. Thus, although the instrument might have completed its specified warm-up period, bandswitching initiates a new coil thermal cycle.

- **Load changes on frequency and on waveform,** which are often characterized by pulling and distortion, respectively, are among the most neglected specifications. Distortion, which can be produced by a number of causes, is especially critical when tests are being conducted on high-fidelity audio equipment.

- **RF shielding** effectiveness is important. The signal generator should deliver its output through the output connector only. RF escaping through other routes can lead to considerable error in sensitivity measurements, and the leakage specification should therefore be noted carefully.

- **Meter indications** are often assumed to offer the accuracy that the specification states. But there is usually more to be said, including, for example, the frequency characteristic. Also, the percent-modulation meter may be specified as accurate to "±10%", but, unless it is known whether this is 10% of full scale or of indicated value, meter accuracy still cannot be assessed.

Incidental FM or AM, modulation envelope symmetry, modulation distortion at various modu-



Comparing competitive units point-by-point is difficult. Considering secondary parameters removes the blindfold.

Frederick Van Veen, Technical Editor, General Radio Co., West Concord, Mass.

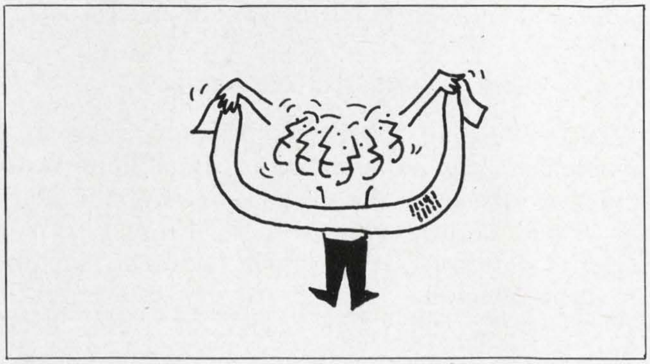
lation levels, intermodulation in the output meter rectifier, the frequency characteristic of modulation—these specifications and many others must be given if the capability of a signal generator is to be known completely. But the coin has another side—one that explains why the completely specified generator will never be made.

Full specification too costly

Specifications cost money. Checking each instrument for the effects of line voltage, temperature, retuning, waveform, etc. could easily add several hundred dollars to the price. No one could afford a completely specified instrument. The manufacturer has to decide how much specification his customers are willing to pay for and proceed accordingly. Thus, from a particular customer's point of view, an instrument may be overspecified or underspecified.

Overspecification is also the fault of the customer who buys more performance than he needs. Many signal generator buyers are probably guilty of overspecification, particularly of output level. A single instrument that tries to be all things to all men is rarely the most economical approach to signal generators, largely because certain features can be bought only at the expense of others. A high power level, for example, works against a generator's stability and leakage characteristics.

Specifying a signal generator may someday be simple and straightforward. The IEEE's Instrumentation and Measurement Group's Technical Committee on High-Frequency Instrumentation and Measurements has a subcommittee working on the problem, and some standards on specifications are sure to result. Meanwhile, as with any product, the best way to ensure that a signal generator is honestly specified is to deal with a reputable manufacturer. You may then be confident that the specifications that are given are accurate. If you need specifications that are *not* given, a letter to the manufacturer should ordinarily bring information on typical performance to be expected. ■ ■



Spec sheets are often incomplete. A letter to the manufacturer should turn up the missing specifications.

Look beyond the listed specs of microwave signal generators to find out about their modulation performance, compatibility and versatility.

A number of factors other than the specifications should be borne in mind whenever you are selecting a microwave signal instrument. The listed specifications are easy-to-measure, well-defined parameters that may tell precious little about the instrument. Often more important than these are two groups of characteristics that are difficult, even impossible, to measure precisely:

- Signal impurities.
- Unmeasurable characteristics.

Signal impurities. Their measurement is possible, but they are so interrelated with other parameters, so hedged about with qualifications, or so dependent on the mode or range of operation, that no simple numerical statement can be made about them. Hence they are seldom published, though the manufacturer is usually able (or should be able) to produce useful data about them.

Unmeasurable characteristics. They are either qualitive considerations like convenience or flexibility, or properties that cannot be measured because no yardstick exists, such as durability.

Certain parameters are usually specified

Altogether there are about 22 criteria that must or should be taken into account when selecting microwave signal instruments. We shall divide them into three groups: usually published parameters, frequently unspecified parameters, and unmeasurable parameters. First, a list of the parameters that are handed to the engineer:

Frequency range—It is the basic specification, arbitrarily determined by the manufacturer. Even though the instrument may perform well beyond the limits of this range, the manufacturer is prepared to guarantee his other specifications only within these specified limits.

Frequency accuracy—It includes all the factors that contribute to the maximum observable difference between any dial setting within the specified frequency range and the actual, absolute value of the output frequency (referred to NBS standards) after stabilization and under standard conditions of ambient temperature, line-voltage level modulation setting. Frequently used standard conditions are 115 volts, 60 Hz unmodulated (cw) line voltage, and 0.0 dBm output.

Frequency stability vs time—When measured after 30 minutes warm-up under standard conditions, a typical figure for a quality instrument is 0.005% per hour, with a maximum drift that keeps the unit within the frequency-accuracy specification.

Frequency stability vs temperature—It is usually specified as a per-cent frequency change per °C over a specified temperature range. Typical values for a commercial instrument are 0.0005%/°C from 0° to 50°C.

Frequency stability vs line voltage—It is usually specified as a per-cent frequency change per one-volt change. A typical microwave signal generator is rated at 0.0003% per one-volt change over a range of ±10% of nominal line voltage.

Accuracy of power-level setting (full scale)—It must include only the energy at the fundamental frequency and exclude harmonics or spurious energy. The result is comparable to absolute NBS standards. The measurement must be performed on an unmodulated signal. The operating conditions should include the lowest-rated line voltage and the highest-rated ambient temperature.

Accuracy of power attenuation—It describes the linearity of the attenuator, i.e., its maximum contribution to the error under the worst combination of setting, frequency and ambient temperature, and with the operating conditions described.

How to check impurities of the output

The next group of parameters, those frequently unspecified, includes a variety of signal impurities and their effects on the modulation envelope. The cw output of a practical, commercial signal instrument is not ideal; it does not have the single-frequency (coherent) waveform that is desirable. However, the degree of deviation from ideal purity in a particular design is rarely stated, except in some general form like "minimum inci-

Nathaniel L. Cohen, Vice President, Marketing, Polarad Electronic Instruments, Long Island City, N. Y.

dental AM and FM." The impurities can be measured, but their complex relationships and the fact that they are not uniformly present over the entire rated frequency range make statements of their measurement complex and difficult.

To cope with these difficulties, a conscientious manufacturer, though he may not publish ratings, maintains "design limits," which should be available to assist the engineer in evaluating the instrument. Here is a list of causes of signal impurities and suggested tolerances:

Hum modulation, AM and FM—Inadequate filtering of the power supplies feeding the oscillator is the prime cause, although magnetic pickup and even electrostatic ac coupling can be significant. In a typical X-band design, the internal design limit might read: "Maximum incidental FM shall not exceed 20 kHz p-p due to power supply ripple and coupling. Maximum AM shall not exceed 0.01% measured under cw conditions."

Noise modulation, AM and FM—This is due primarily to noise generated in the microwave oscillator tube or transistor; more specifically, beam noise in klystron or other velocity-type tube is the culprit. A typical design-limit statement might read: "Maximum integrated noise sideband power shall not exceed −60 dB referred to the unmodulated carrier."

Harmonic Content—Invariably generated by the oscillator, this is never completely attenuated by the Q of the cavity, high though that may be. A typical design limit may be stated as: "Total harmonic content shall not exceed −40 dBm."

Flicker—Several sources contribute to this: line transients and spikes, imperfect joints (e.g., sliding contacts) in RF plumbing, and erratic "pulling" (or intermittent "moding") in a marginal oscillator circuit. In a well-designed signal instrument, this should not be a measurable parameter. Typically, flicker modulation should not exceed −60 dB over more than 1% of operating time, or −50 dB over 0.01% of the time.

Modulation characteristics and anomalies are often as hard to determine from a written specification as are cw characteristics and behavior. The following points should not be overlooked:

Splatter—It results from an inadequate dynamic modulation range and should never be present when a device is operated under a specified range of modulation conditions. Attempts to operate an instrument at a higher than the specified modulation percentage may result in serious splatter.

Anomalous sidebands—Distortion in the modulation process can generate dozens of large, confusing, and sometimes intolerable spurious sidebands. In a good general-purpose design, the total energy of all such sidebands should not exceed 1% of the total sideband energy.

Spectral assymetry—This is usually due to some combination of factors, including limited modulation range, high and nonlinear power supply impedance, marginal fidelity in the modulation circuit, and non-ideal modulating signals.

Any one of the above departures from absolute signal purity can cause expensive, time-wasting, and perhaps even destructive malfunctioning in a system. For example, large signal impurity can throw off level reading by several decibels, produce strange "detuning" effects and generate unrecognizable modulation envelopes. Only by assuring himself that the instrument designer has anticipated and minimized signal anomalies can the engineer avoid such problems.

Imperfections in the modulating signal are difficult to define with precision. However, it is necessary to check that each of the following has been standardized to acceptable limits:

Pulse-modulation fidelity of envelope—Typical design-limit specifications are: Rise and decay time shall not exceed 0.15 μs. Neither overshoot nor undershoot should be more than 5%. Flatness of pulse top should be 1% on narrow pulses, 5% on wide pulses.

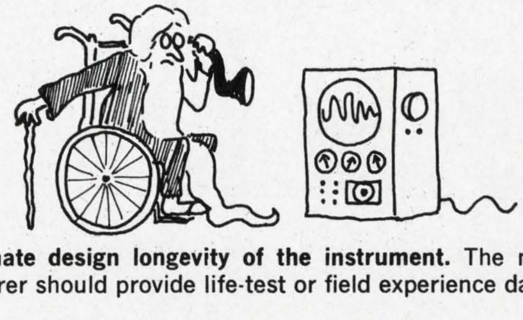
Sawtooth modulation fidelity of envelope—Typical design-limit specifications are: RF output should track modulating waveform within 3% for all modulation levels between 10 and 90%.

Sine-wave modulation fidelity of envelope—Typical design-limit specifications are: Modulation envelope distortion should not exceed 5% total over a range of 0 to 50%.

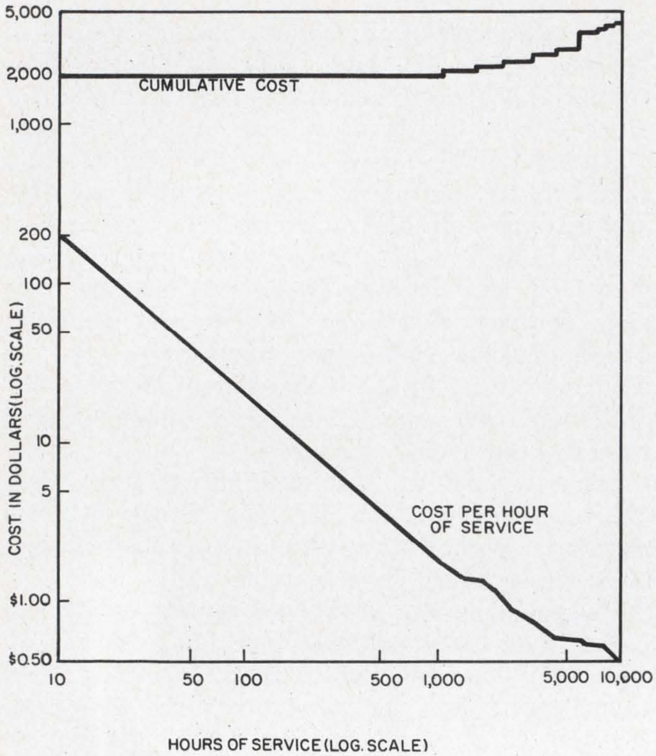
Indefinable qualities can be quite definitive

Even though the instrument passes all the previous tests with flying colors, there are still some hurdles left. The last group of criteria are those unmeasurable qualities that make or break a line. These usually fall into two main categories: One we may call "functional reliability" or "design longevity," and the other, simply, "convenience and flexibility."

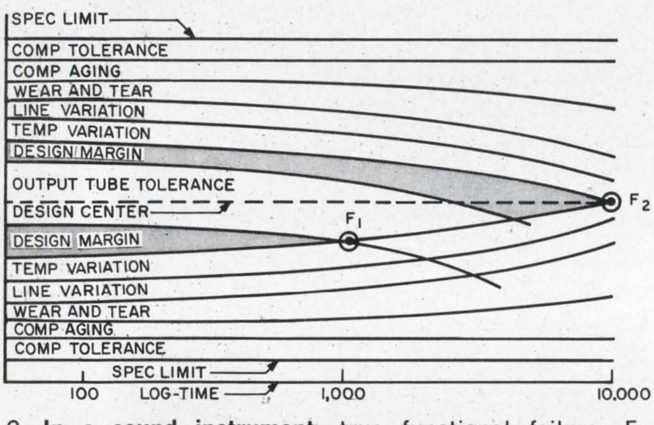
Functional reliability is a measure of the probability that an instrument, purchased today, will function in accordance with its specifications at a given time in the future. Failure to do so need not be catastrophic or even apparent. A manufacturer should be able to assure you, by showing life-test or field-experience data, that his instrument will,



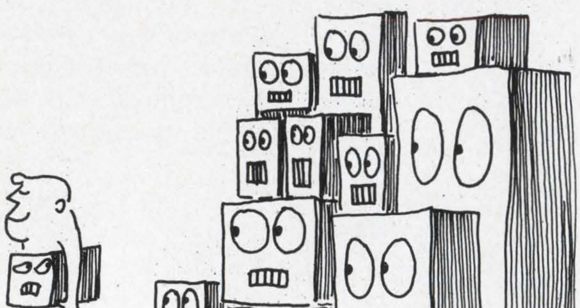
Estimate design longevity of the instrument. The manufacturer should provide life-test or field experience data.



1. **Typical cost factors** associated with the operation of a signal generator are shown in terms of initial cost and routine maintenance expenses through the life of the instrument.



2. **In a sound instrument,** true functional failure, F_2, must occur later than the end of useful life. The functional failure analysis has been prepared for power output in this graph. F_1 represents a renewable point in the life of the instrument.



Pick your purchase from a modular family. Future compatibility and functional modularity are important.

in all probability, provide full, functional reliability for a period of years.

Note that "functional failure" exists whenever the instrument is capable of operating outside the specified limits, even if the user never actually happens to apply a combination of stresses that would force it beyond them.

Anomalous behavior is a kind of functional failure, even if it is within the specified limits. For instance, an instrument's level calibration error may manifest itself as a drift upward and then suddenly change to a downward drift. This uncharacteristic behavior may paralyze an experiment, or at least delay it while the reason for it is hunted down, even though the drift remains within the permitted range.

Renewability—A common shortcoming of inferior instruments is that they are based on marginal designs that have very narrow tolerances. When a component fails, the unit cannot always be repaired such that it will again perform according to all of its original specifications, even when factory-supplied standard parts are used. To guard against this type of design, the engineer should make sure that the manufacturer has observed adequate margins to guarantee renewability. A typical set of curves used by Polarad to establish design margins is shown in Fig. 1. The cost of maintaining an instrument is compared with the cost of replacement in Fig. 2.

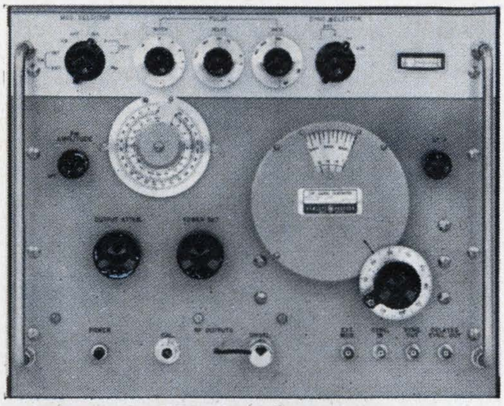
Versatility—In how many different ways can it be used in addition to that for which it is originally purchased? How much of the time will it be in use? Will it be compatible with most associated equipment, and in how many combinations? These and similar questions become important when selecting an instrument for laboratory use on a specific project with the expectation that it will later be available for other work. The manufacturer should be able to show features that demonstrate the wide applicability of his instrument.

Functional modularity—Look beyond the specific instrument to the other members of its family. When a line of instruments is considered as an integrated set (of measuring facilities, for example), each unit by itself should be suited to a sizeable range of applications without wasteful duplication, overlap or compromise in performance. You have a right to ask: "Can the same doubler be driven by each of a family of generators? Will the modulator module drive every one of the sources and generators in the line?"

Future compatibility—When purchasing one or more designs in a line of instrument modules, engineers should ask: "Can we be sure that our future needs for this kind of instrumentation can be met by adding one or more compatible existing modules from the same family?" Once again, it is necessary to look beyond the specifications. ■ ■

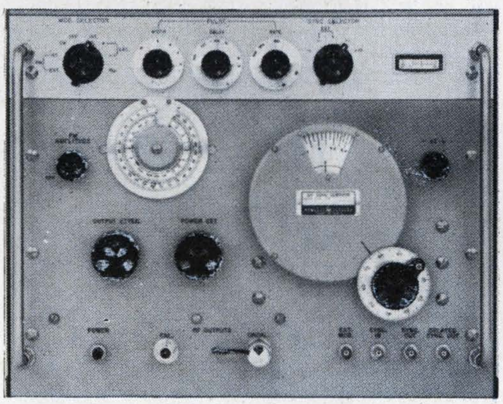
another series of

Improved Signal Generators



618C Signal Generator

3.8-7.6 GHz



620B Signal Generator

7-11 GHz

Very low residual FM; cleaner signals mean more accurate measurement results

High level auxiliary rf output; can phase-lock or count frequency

New power monitor without "zero set"; simplified operation

High performance, lighter weight power supplies

These improved signal generators from Hewlett-Packard offer new standards of highly accurate and stable test signals. The new power supplies result in the lower residual FM (10 kHz p-p max.) and decrease the weight of the instruments. The auxiliary rf output allows you to phase-lock the signal generators with the Dymec 2650A Oscillator Synchronizer to provide crystal oscillator stability at microwave frequencies. It also can be used with an electronic counter for utmost precision in monitoring frequency.

Ultra-fine tuning capability is assured with the addition of a Δ F frequency vernier control. A new crystal detector type power monitor eliminates zero setting; operation is simplified with less chance for operator error.

Brief specs are listed here. Call your Hewlett-Packard field engineer for complete information or write Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

SPECIFICATIONS	hp 618C, 620B Signal Generators
Frequency range:	hp 618C, 3.8 to 7.6 GHz; hp 620B, 7 to 11 GHz
Frequency calibration:	Direct reading, accuracy better than $\pm 1\%$
Frequency stability:	$<0.006\%/°C$ change in ambient temp.; $<0.02\%$ change for $\pm 10\%$ line voltage variation
Residual FM:	hp 618C, ≤ 8 kHz p-p; hp 620B, ≤ 10 kHz p-p
Calibrated RF output range:	1 mw or 0.224 v to 0.1 μv (0 dbm to −127 dbm) into 50Ω
Output accuracy:	Within ± 2 db from −7 dbm to −127 dbm
Aux. RF output:	Fixed level of at least 0.3 mw
Modulation:	Pulse, square wave, FM; internal or external
Weight:	Net 63 lbs (29 kg)
Price:	hp 618C, hp 620B, $2250; rack mount add $20.

Data subject to change without notice.
Prices f.o.b. factory.

HEWLETT hp PACKARD
An extra measure of quality

ON READER-SERVICE CARD CIRCLE 170

Signal generators 1.62-420 MHz

For information on how to use these tables, turn to page 2

			FREQUENCY					OUTPUT					
	Manufacturer	Model	Min. MHz	Max. MHz	Acc. %	Stab. ppm	# of ranges	Min. µV	Max. V	Modulation	Type	Price $	Notes
SG-1	Sierra	350A	.005	1.62	±2 kHz	ina	2	-90 dBm	+10 dBm	ina	C	895	
	Tel-Inst	1902A	4.5	4.5	ina	xtal	1	ina	0.75	AM,FM	C	480	
	H-P	618C	3.8	7.6	1	60	1	0.1	0.224	AM,FM,Pulse	C,R	2250	
	H-P	620B	7	11	1	60	1	0.1	0.224	AM,FM,Pulse	C,R	2250	
	Grundig	AS2	0.1	11.2	ina	ina	12	-130 dB	0.5	AM	C	275	
	Sierra	351A	.01	15	±10 ppm	ina	1	-90 dBm	0 dBm	ina	C,R	2950	
	R & S	SMLR	0.1	30	±1	50	5	1	10	AM,FM	C	1490	
	Measurements	65B	.075	30	0.5	ina	6	0.1	2.2	AM	C	875	
	Heath	IG-42	0.1	31	±3	ina	5	ina	0.1	AM	C	56 kit	
	R & S	SMAR	29 Hz	31	±0.5	30	6	.01	10	AM,FM	C	5995	
SG-2	Clough-Brengle	299A	0.1	32	0.5	ina	5	0.5	0.1	AM	C	275	
	RCA	WR-50B	.085	40	±2	ina	6	50 mV	ina	AM	C	65	
	Measurements	82	.08	50	1	ina	7	0.1	1	AM	C	660	
	Gen Radio	1001A	.005	50	±1	2500	8	0.1	0.282	AM	C	1195	
	R & S	SMDH	0	50	.002 ppm	.001 ppm	2	0.1	2.5	FM	C,R	11,600	
	Measurements	210S	24	52	0.5	ina	1	0.1	0.1	FM	C	475	
	H-P	606B	.05	65	1	50	6	0.1	3	AM,FM	C,R	1550	
	Gertsch	SG-8	.05	65	±1	.005%	6	0.1	3	AM	R	1345	b
	H-P	606A	.05	65	1	50	6	0.1	3	AM,FM	C,R	1350	b
	Marconi	2002	.01	72	±1	10	8	0.1	.08	AM	C,R	2495	
SG-3	Measurements	210R	50	80	0.5	ina	1	0.1	0.1	FM	C	475	
	AMI	304	5	100	±0.5	±.005%	1	0.1	0.1	FM	C,R	1785	b
	Piezo	SG-12A/U	1.4	102	0.5	ina	14	.05	1	FM	C	2500	
	EICO	320	0.15	102	ina	ina	7	ina	.07	AM	C	30	
	Measurements	88	86	108	0.5	ina	1	0.1	0.1	FM	C	585	
	Measurements	210A	86	108	0.5	ina	1	0.1	0.1	FM	C	450	
	Heath	IG-102	100	110	2	ina	6	ina	0.1	AM	C	30 kit	
	EMC	502	0.115	110	±1.5	ina	6	ina	0.1	AM	C	27	
	Radiometer	MS111	.01	110	1.5	0.2%	12	0.2	0.2	AM,FM	C	1008	
	Kay	5070	10	120	±1	ina	5	107 dB	3	Pulse	C,R	875	
SG-4	Aircraft Radio	H-14-A	108	132	.005	ina	2	1	100	AM	C	1696	
	H-P	211A	88	140	0.1	50	1	0.1	0.2	AM,FM	R	2190	
	EICO	315	75	150	1	ina	7	ina	0.1	AM	C	60	
	Microdot	440/167RF	1	150	.0008	.0005%	1	0.1	1	AM,FM,Pulse	R	request	
	Measurements	210B	148	174	0.5	ina	1	0.1	0.1	FM	C	450	
	Motorola	T-1036-A	25	175	0.5	ina	6	0.1	0.1	FM	C	793	
	Hickok	295X	0.125	175	1	ina	8	0.1	0.1	AM	C,R	655	
	AMI	302	20	200	±0.5	±.005%	1	0.1	0.1	FM	C,R	1950	
	H-P	202H	54	216	±0.5	100	2	0.1	0.2	AM,FM,Pulse	C,R	1475	
	Radiometer	MS26	54	216	0.5	ina	2	.05	0.2	AM,FM	C	1533	
SG-5	Marconi	995A/2	1.5	220	1	25	5	1	0.1	AM,FM	C	1145	
	Triplett	3432A	0.16	220	2	ina	8	ina	ina	AM	C	130	
	Precise	612	0.1	220	1	ina	6	20	0.1	AM,FM	C	80	
	Radiometer	MS27	0.3	240	0.5	ina	5	0.2	0.2	AM,FM	C	1270	
	Gen Radio	1021-AV	40	250	1	ina	2	0.5	1	AM	C	895	
	RS	1021VHF	216	260	ina	±.01%	1	0.1	.07	FM	C	2950	a
	RS	5036-3	216[1]	260	ina	.015%	1	0.1	0.1	FM	C,R	request	
	RS	1003	216	260	±0.5	.015%	1	0.1	0.1	FM	C,R	2925	
	H-P	202J	195	270	±0.5	200	1	0.1	0.2	AM,FM,Pulse	C,R	1595	
	Microdot	440/140-4RF	200	275	.0008	.0006%	1	0.1	1	FM	R	request	
SG-6	R & S	ASV	30	300	±2	ina	1	30 mV	3	AM,FM	C	850	
	R & S	SMLM	30	300	±1	30	6	3 mV	3	AM,FM	C	1395	
	R & S	SMAF	4	300	±1	50	8	.05	50	AM,FM	C	2995	
	H-P	232A	329.3	335	.0065	ina	2	1	0.2	AM	C	1920	
	Measurements	95	50	400	0.5	ina	3	0.1	0.1	FM	C	1800	
	EPSCO	SG-132A	15	400	0.5	50	6	0.1	0.15	AM,FM	C,R	2400	
	Measurements	80	2	400	0.5	ina	6	0.1	0.1	AM,Pulse	C	590	
	AMI	303A	215	420	±0.5	±.005%	1	0.1	0.1	FM	C,R	1900	
	H-P	608D	10	420	0.5	10	5	0.1	0.5	AM,FM,Pulse	C,R	1300	b
	Gertsch	SG-9	10	420	±0.5	.005%	5	0.1	0.5	AM	R	1295	b

Notes, abbreviations and manufacturers' index at end of this section.

Signal generators 435-7600 MHz

			FREQUENCY					OUTPUT					
	Manufacturer	Model	Min. MHz	Max. MHz	Acc. %	Stab. ppm	# of ranges	Min. µV	Max. V	Modulation	Type	Price $	Notes
SG-7	EICO	324	0.15	435	1.5	ina	7	ina	0.1	AM	C	40	
	H-P	608F	10	455	1	50	5	0.1	0.5	AM,FM,Pulse	C,R	1600	
	Marconi	1064B/2	30	470	0.5	25	3	0.25	.01	FM	C	795	
	Motorola	T1035-A	25	470	0.5	ina	6	0.1	0.1	FM	C	793	
	Measurements	M-673	25	470	0.5	ina	6	0.1	0.1	FM	C	698	
	Marconi	1066B/6	10	470	±1	0.15%	5	0.1	0.1	AM,FM	C,R	1895	
	Marconi	1066B/1	10	470	1	25	5	0.2	0.1	AM,FM	C,R	1650	
	Marconi	801D/1	10	470	0.2	50	5	0.1	0.5	AM,FM,Pulse	C	1615	
	Measurements	80R	5	475	0.5	ina	6	0.1	0.1	AM,Pulse	C	625	
	R & S	SLSV	25	480	±1	50	7	ina	3.5	AM	C	1695	
SG-8	H-P	608E	10	480	0.5	100	5	0.1	1	AM,FM,Pulse	C,R	1450	
	H-P	608C	10	480	1	50	5	0.1	1	AM,FM,Pulse	C,R	1200	b
	Gertsch	FM-9	150	486	±.0002	ina	2	0.5	.05	FM	C	1495	
	Clough-Brengle	555	10	490	0.5	250	8	0.2	0.2	AM	C	485	
	H-P	3200B	10	500	±2	20	6	1	3.1	AM	C,R	475	
	Gertsch	SSG-1	5 Hz	500	±.00001	.00001%	12	-130 dBm	0 dBm	AM	C	12,500	
	R & S	SMFA	1.39	510	±0.5	ina	12	.03	1	AM,FM	C	7920	
	AMI	303H	380	520	±0.5	±.005%	1	0.1	0.3	FM	C,R	2800	
	RS	1021UHF	406	549	ina	±.005%	1	0.1	.07	FM	C	2950	a
	Babcock	BSG-17D	406	550	±.005	ina	1	1	0.1	FM	R	5600	
SG-9	AMI	303B	400	550	±0.5	.0025%	1	0.1	0.1	FM	C,R	1950	
	RS	1001	400	550	±0.5	.015%	1	0.1	0.1	FM	C,R	2925	
	Microdot	440/143-4RF	400	550	.0003	.0006%	1	0.1	1	FM	R	request	
	RS	5036-1	400 [1]	550	ina	.015%	1	0.1	0.1	FM	C,R	request	
	Microdot	412A	400	550	.0003	.0005%	1	0.1	1	FM	C	9950	
	Smyth	606	38	600	±.005	±.002%	1	-30 dBm	-160 dBm	AM,FM	R	1295	
	AMI	303	225	800	±0.5	±.05%	1	0.1	0.1	FM	C,R	3600	b
	Gen Radio	1021-AU	250	940	1	ina	1	0.5	1	AM	C	895	
	R & S	SDAF	170	940	±1	50	9	0.5	0.5	AM,FM,Pulse	C	4090	
	Marconi	1060/3	470	960	±1	50	1	.07	0.223	AM,FM	C,R	1895	
SG-10	Motorola	T1034-C	25	960	0.5	ina	6	0.1	0.1	FM	C	728	
	Measurements	560FM	25	960	0.5	ina	6	0.1	0.1	FM	C	648	
	Measurements	84TVR	400	1000	0.5	ina	1	0.1	0.3	AM,FM	C	785	
	R & S	SDR	300	1000	±1	50	8	1	3.5	AM,Pulse	C	2520	
	Gertsch	FM-7	20	1000	±.0002	±1	1	note 6	note 6	AM,FM	C,R	1625	
	Gertsch	SG-10	400	1200	±1	ina	1	0.1	0.5	AM	R	1395	b
	H-P	8925A	962	1213	note 5	ina	1	-100 dBm	-10 dBm	Pulse	C	12,090	
	H-P	612A	450	1230	1	ina	1	0.1	0.5	AM,FM,Pulse	C,R	1400	b
	RS	1041L	1435	1535	ina	.0005%	1	-20 dBm	-120 dBm	FM	C,R	2950	
	Microdot	440/145-4RF	1435	1555	.0005	.0006%	1	0.1	1	FM	R	request	
SG-11	R & S	SCR	1000	1900	±1	50	4	1	2.7	AM	C	2190	
	EPSCO	SG-161	900	2100	±1	.005%	1	0.2	0.223	Pulse	C,R	1700	
	H-P	614A	800	2100	1	50	1	0.1	0.224	FM,Pulse	C,R	1950	b
	Gertsch	SG-11	900	2200	±0.5	ina	1	0.1	0.223	FM,Pulse	C	request	
	RS	1041S	2200	2300	ina	.0005%	1	-20 dBm	-120 dBm	FM	C,R	2950	
	H-P	8614A	800	2400	±0.5	50	1	-127 dBm	+10 dBm	AM,FM,Pulse	C,R	2100	b
	H-P	8614B	800	2400	±0.5	50	1	note 2	15 mW	AM,FM,Pulse	C,R	1450	b
	R & S	SBR	1700	2700	±1	50	1	1	2	AM	C	2320	
	R & S	SLRD	275	2750	2	50	2	-80 dB	ina	AM	C	3995	
	Polarad	MSG-1R/2R-G24P	2400	4000	1	50	1	-127 dBm	+10 dBm	AM,FM,Pulse	C,R	2250	b,c
SG-12	R & S	SAR	2700	4200	±1	20	1	5	3.4	AM	C	2930	
	H-P	616B	1800	4200	1	50	1	0.1	0.223	AM,FM,Pulse	C,R	1950	b
	EPSCO	SG-153A	1800	4200	±1	.005%	1	0.1	0.233	FM,Pulse	C,R	1750	
	Gertsch	SG-12	1800	4400	±0.5	ina	1	0.1	0.223	FM,Pulse	C	request	
	H-P	8616A	1800	4500	±10 MHz	50	1	-127 dBm	±10 dBm	AM,FM,Pulse	C,R	2100	b
	H-P	8616B	1800	4500	±10 MHz	50	1	note 2	15 mW	AM,FM,Pulse	C,R	1450	b
	Polarad	MSG-1R/2R-G24	2000	4600	1	50	1	-127 dBm	0 dBm	AM,FM,Pulse	C,R	1950	b,c
	R & S	SLRC	2300	7000	±1.5	50	1	100 mW	3 W	FM,Pulse	C	6600	
	Gertsch	SG-13	3800	7600	±0.5	ina	1	0.1	0.223	FM,Pulse	C	request	
	EPSCO	SG-152	3800	7600	1	.006%	1	0.1	0.223	AM,FM,Pulse	C,R	2025	

Notes, abbreviations and manufacturers' index at end of this section.

Signal generators 7780-39,700 MHz

	Manufacturer	Model	FREQUENCY Min. MHz	Max. MHz	Acc. %	Stab. ppm	# of ranges	OUTPUT Min. μV	Max. V	Modulation	Type	Price $	Notes
SG-13	Dymec	623B	5820	7780	.03	ina	1	70	0.223	AM,FM	C	2250	
	Polarad	1107	3800	8200	±0.5	50	1	-127 dBm	+3 dBm	AM,FM	R	1900	b
	Polarad	1207	3800	8200	±0.5	ina	1	50 mW	ina	AM,FM	R	1425	b
	Dymec	DY-5636	7100	8500	±.03	ina	1	+15 dBm	-85 dBm	AM,FM,Pulse	C	3800	
	Dymec	624C	8500	10,000	.03	ina	1	2.23	0.223	AM,FM,Pulse	C,R	2265	
	Smyth	608	600	10,000	±.005	±.002%	1	-30 dBm	-160 dBm	AM,FM	R	2-3000(3)	
	Gertsch	SG-14	7000	11,000	±0.5	ina	1	0.1	0.223	FM,Pulse	C	request	
	EPSCO	SG-184	7000	11,000	1	.006%	1	0.1	0.223	AM,FM,Pulse	C,R	2050	
	Polarad	1108	6950	11,000	±0.5	ina	1	-127 dBm	+3 dBm	AM,FM,Pulse	R	1900	b
	Polarad	1208	6950	11,000	±0.5	50	1	25 mW	ina	AM,FM,Pulse	R	1425	b
SG-14	Polarad	MSG-34	4200	11,000	1	100	1	0.1	0.223	AM,FM,Pulse	C	3680	
	R & S	SMCK	1700	11,400	±1	10	note 5	3 mW	120 mW	AM,FM	C	note 5	
	H-P	626A	10,000	15,500	1	ina	1	-90 dBm	+10 dBm	AM,FM,Pulse	C,R	3400	b
	H-P	628A	15,000	21,000	1	ina	1	-90 dBm	+10 dBm	AM,FM,Pulse	C,R	3400	b
	Polarad	EHF-G1822	18,000	22,000	0.1	ina	1	-90 dBm	-10 dBm	AM,FM,Pulse	C	3315	c
	Polarad	EHF-G2225	22,000	25,000	0.1	ina	1	-90 dBm	-10 dBm	AM,FM,Pulse	C	3315	c
	Polarad	EHF-G2427	24,700	27,500	0.1	ina	1	-90 dBm	-10 dBm	AM,FM,Pulse	C	3315	c
	Polarad	EHF-G2730	27,270	30,000	0.1	ina	1	-90 dBm	-10 dBm	AM,FM,Pulse	C	3340	c
	Polarad	EHF-G3033	29,700	33,520	0.1	ina	1	-90 dBm	-10 dBm	AM,FM,Pulse	C	3340	c
	Polarad	EHF-G3336	33,530	36,250	0.1	ina	1	-90 dBm	-10 dBm	AM,FM,Pulse	C	3340	c
	Polarad	EHF-G3540	35,100	39,700	0.1	ina	1	-90 dBm	-10 dBm	AM,FM,Pulse	C	3340	c

Signal generators Late arrivals

SG-15	Dynatronics	DFS-23	1700	1709.99	ina	±3	1	-170 dBm	-130 dBm	AM,Phase	R	request	
	Dynatronics	DFS-23A	1700	1709.99	ina	±3	1	-170 dBm	-130 dBm	AM,FM,Phase	R	request	
	Dynatronics	DFS-22	400	405.999	ina	±3	1	-170 dBm	-20 dBm	AM,Phase	R	request	
	Dynatronics	DFS-22A	400	405.999	ina	±3	1	-170 dBm	-20 dBm	AM,FM,Phase	R	request	
	Dynatronics	DFS-21A	136	137.99	ina	±3	1	-160 dBm	-20 dBm	AM,Phase	R	request	

Notes, abbreviations and manufacturers' index at end of this section.

NOTES

a. Battery operated.
b. Input voltage, 115 or 230 V, ±10%, 50-60 Hz, 1 phase.
c. Prices shown are for tuning unit and basic power supply. The basic power supply can be used with any of this series of tuning heads.

1. Monitored by built-in frequency counter.
2. Attenuator range 130 dB.
3. Depending on RF unit desired.
4. Three separate oscillator units available, 1.7-5 GHz, $4110; 4.4-8.3 GHz, $4150; 8-11.4 GHz, $4400.
5. Determined by frequency counter setting.
6. Fundamental range 20-40 MHz, output 0.4 V across 50 ohms; harmonics, 40-100 MHz, output .002 V minimum across 50 ohms.

ABBREVIATIONS

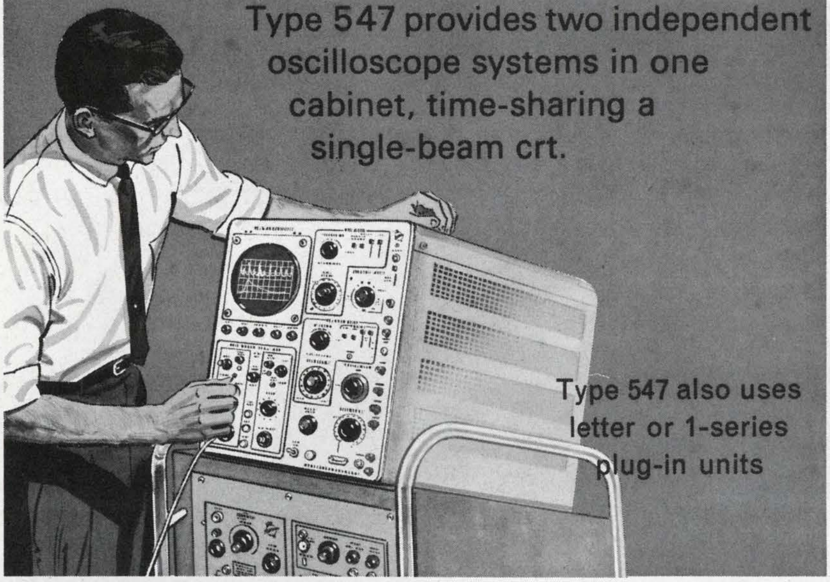
- C Cabinet.
- R Rack mount.
- ina Information not available.
- xtal Crystal.

Tektronix oscilloscope displays both time-bases separately or alternately

TYPE 547 and 1A1 UNIT

DUAL TRACE	**DC-to-50 MHz** **50 MV/CM** DC-TO-28 MHz, 5 MV/CM
SINGLE TRACE	**2 Hz-to-15 MHz** **500 μV/CM** (CHANNELS 1 AND 2 CASCADED)

With automatic display switching, the Type 547 provides two independent oscilloscope systems in one cabinet, time-sharing a single-beam crt.



Type 547 also uses letter or 1-series plug-in units

Some Type 547/1A1 Unit Features

CRT (with internal graticule and controllable illumination) provides bright "no-parallax" displays of small spot size and uniform focus over the full 6-cm by 10-cm viewing area.

Calibrated Sweep Delay extends continuously from 0.1 microsecond to 50 seconds.

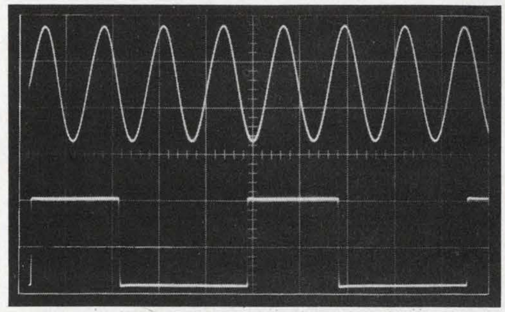
2 Independent Sweep Systems provide 24 calibrated time-base rates from 5 sec/cm to 0.1 μsec/cm. Three magnified positions of 2X, 5X, and 10X, are common to both sweeps—with the 10X magnifier increasing the maximum calibrated sweep rates to 10 nsec/cm.

Single Sweep Operation enables one-shot displays for photography of *either* normal or delayed sweeps, including alternate presentations.

2 Independent Triggering Systems simplify set-up procedures, provide stable displays over the full passband and to beyond 50 MHz, and include brightline automatic modes for convenience.

Type 547 Oscilloscope (without plug-in unit)	$1875
Type 1A1 Dual-Trace Unit	$ 600
Rack-Mount Model Type RM547	$1975

U.S. Sales Prices f.o.b. Beaverton, Oregon



Single-exposure photograph.

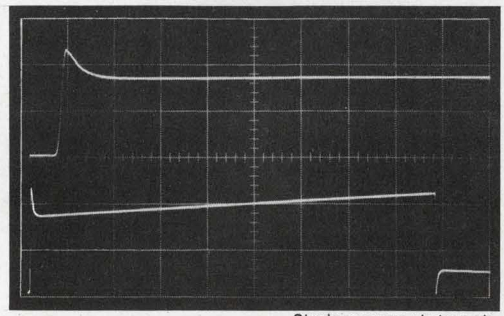
2 signals — different sweeps

Upper trace is Channel 1/A sweep, 1 μsec/cm.
Lower trace is Channel 2/B sweep, 10 μsec/cm.

Using same or different sweep rates (and sensitivities) to alternately display different signals provides equivalent dual-scope operation, in many instances.

Triggering internally (normal) permits viewing stable displays of waveforms unrelated in frequency.

Triggering internally (plug-in, Channel 1) permits viewing frequency or phase differences with respect to Channel 1.

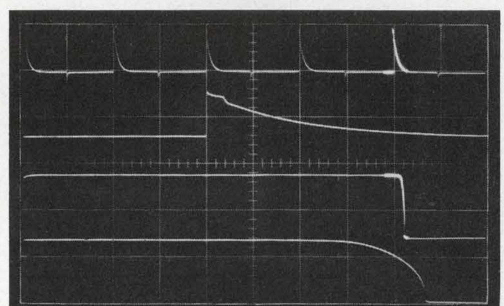


Single-exposure photograph.

same signal — different sweeps

Upper trace is Channel 1/A sweep, 0.1 μsec/cm.
Lower trace is Channel 1/B sweep, 1 μsec/cm.

Using different sweep rates to alternately display the same signal permits close analysis of waveform aberrations in different time domains.



Single-exposure photograph.

2 signals — portions of each magnified

Trace 1 is Channel 2/B sweep, 10 μsec/cm.
Trace 2 (brightened portion of Trace 1) is Channel 2/A sweep, 0.5 μsec/cm.
Trace 3 is Channel 1/B sweep, 10 μsec/cm.
Trace 4 (brightened portion of Trace 3) is Channel 1/A sweep, 0.5 μsec/cm.

Using sweep delay technique—plus automatic alternate switching of the time bases—permits displaying both signals with a selected brightened portion and the brightened portions expanded to a full 10 centimeters.

B sweep triggering internally from Channel 1 (plug-in) assures a stable time-related display without using external trigger probe.

Tektronix, Inc.

For complete information, contact your nearby Tektronix field engineer or write:
Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005

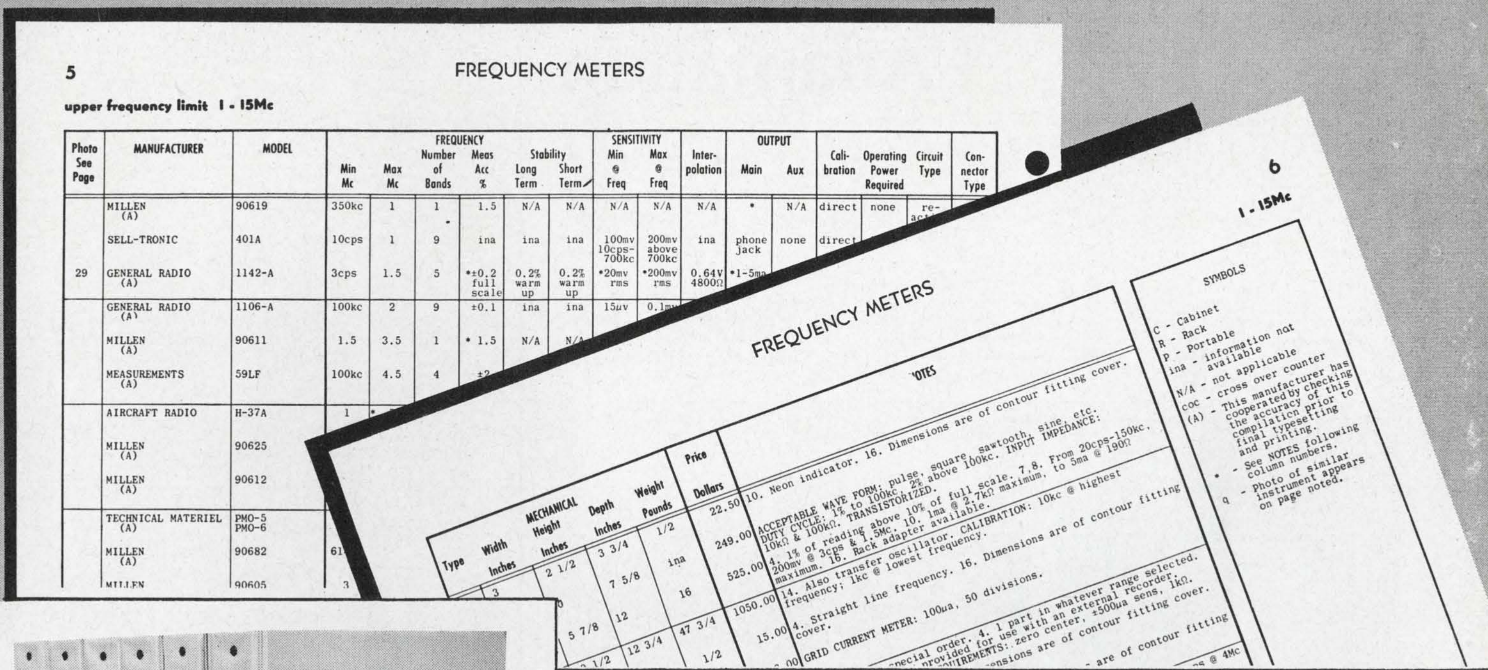
ON READER-SERVICE CARD CIRCLE 171

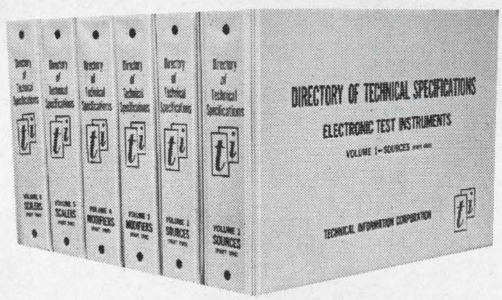
Index of Manufacturers and Model Numbers

(keyed to table locator symbols)

The Standard Reference For Electronic Test Instruments

DIRECTORY OF TECHNICAL SPECIFICATIONS





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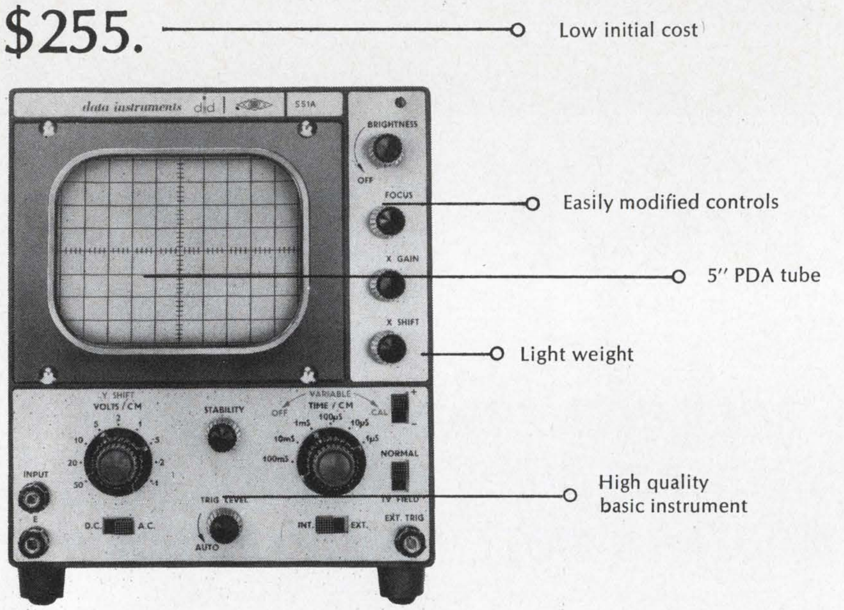
Designed for Adaptation



Here is the practical oscilloscope for special applications—Data Instruments S51. This scope is designed for modification both physically and electrically and has a history of success in large volume OEM equipments as well as single installations. Versions of the S51 are currently performing with unusual success in medical applications for which new sensitivities were installed and controls were tailored to the habits of the personnel using them. The S51 is also used as original equipment in consoles of standard data handling and process control systems and has gained wide acceptance for use on assembly line testing and for educational purposes. The features that make the S51 particularly suitable for adaptation are: (a) The low initial cost of the instrument—$255. (b) The large sophisticated CRT, which is capable of handling a broad range of requirements without additional circuitry. (c) The open construction which simplifies the physical problems of modification. (d) Its extremely light weight (16 lbs). And (e) the high quality and performance of the basic instrument. Its specifications are:

VERTICAL AMPLIFIER				
BANDWIDTH	SENSITIVITY/CM	ATTENUATOR	IMPEDANCE	ACCURACY
DC-3MHz	100mv to 50v	9 position	1MΩ+30pf	±5%

TIME BASE		CRT			PHYSICAL
SPEED/CM	TRIGGER & HOR. AMP.	DIA.	PHOSPHOR	VOLTS	DIM. & WT.
1μs-0.1sec. (6 ranges)	Exp. x 2 5Hz-200KHz	5″ PDA	P1, P7	3.5kv	15½″x8″x7″ 16 lbs

Data Instruments maintains a staff of engineers experienced in special installations. If you have an unusual requirement for an oscilloscope, the chances are the S51 can be modified to do the job.

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ON READER-SERVICE CARD CIRCLE 174

211A (SG-4)
232A (SG-6)
606A (SG-2)
606B (SG-2)
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608D (SG-6)
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608F (SG-7)
612A (SG-10)
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8614A (SG-11)
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8616B (SG-12)
8925A (SG-10)

Hickok Electrical Instrument Co

295X (SG-4)

Kay Electric Co

5070 (SG-3)

Marconi Instruments

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995A/2 (SG-5)
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1064B/2 (SG-7)
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Microdot, Inc

412A (SG-9)
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440/143-4RF (SG-9)
440/145-4RF (SG-10)
440/167RF (SG-4)

Motorola Communications & Electronics, Inc

T-1034C (SG-10)
T-1035-A (SG-7)
T-1036-A (SG-4)

Piezo Technology

SG-12A/U (SG-3)

Polarad Electronic Instruments

EHF-G1822 (SG-14)
EHF-G2225 (SG-14)
EHF-G2427 (SG-14)
EHF-G2730 (SG-14)
EHF-G3033 (SG-14)
EHF-G3336 (SG-14)
EHF-G3540 (SG-14)
MSG-1R/2R-G24P (SG-11)
MSG-1R/2R-G24 (SG-12)

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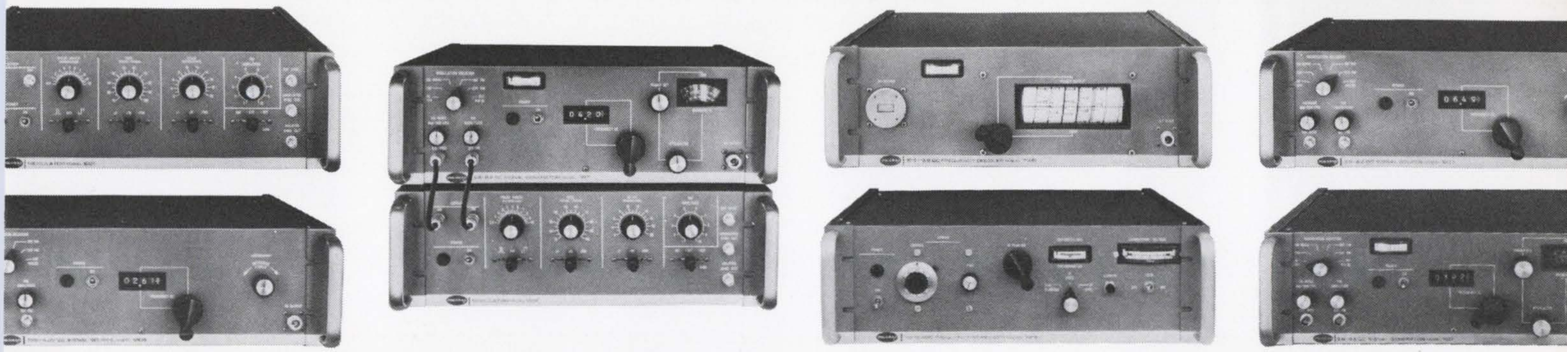

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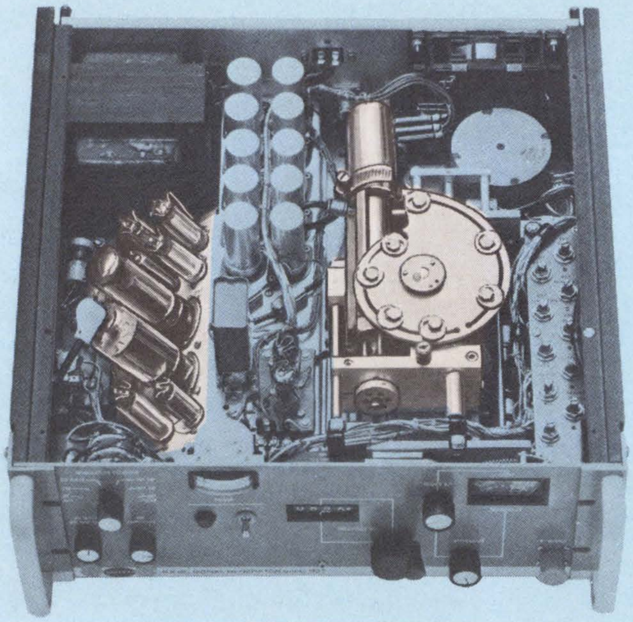

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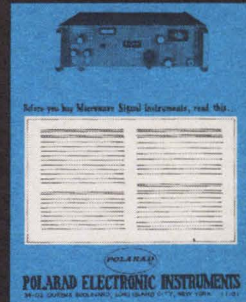

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MSG-34 (SG-14)
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1021VHF (SG-5)
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5036-1 (SG-9)
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351A (SG-1)

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SG-9 (SG-6)
SG-10 (SG-10)
SG-11 (SG-11)
SG-12 (SG-12)
SG-13 (SG-12)
SG-14 (SG-13)
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606 (SG-9)
608 (SG-13)

Tel-Instrument Electronics Corp (Tel-Inst)

1902A (SG-1)

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3432A (SG-5)

Manufacturers' addresses and literature offerings in master cross index at front of issue.

◀ ON READER-SERVICE CARD CIRCLE 175

ON READER-SERVICE CARD CIRCLE 176

Sweep away drift problems in narrow-band receiver tests. Use a sweep generator and scope for sensitivity and signal-to-noise measurement.

Drift problems in a narrow-band communications receiver are relatively easy to overcome—just use a crystal oscillator rather than LC circuits. But what's the answer to drift in the signal generator testing the receiver? Variable tuning for a generator is a necessity to accomplish such basic tasks as out-of-band rejection tests. Frequency synthesizers can be used as a master oscillator, but, this is an expensive solution.

A more economical solution is found simply by varying the measuring technique. Use a frequency-swept signal with the receiver's output displayed on a scope. Benefits are threefold:

- The test set-up is basically the same for all receivers. (Fig. 1).
- The test sequence is simple, quick and without calculation.
- Generator frequency drift is no longer a consideration.

In addition to the often-used bandwidth and selectivity measurements, sweep frequency techniques may be applied to determine sensitivity and signal-to-noise ratio for single sideband (SSB) and telegraphy receivers—both AM and FM.

SSB and telegraphy receivers are simplest

Despite often exacting specs, SSB and telegraphy receivers are, in one respect, the easiest to test. Their general performance can be measured by using an unmodulated cw signal to simulate the wanted sideband. Since the test signal does not have to be modulated, noise-limited sensitivity can be read from a single display.

Receiver sensitivity is usually stated in terms of that input level necessary to obtain a specified signal-to-noise ratio (noise-limited sensitivity). In the case of an SSB receiver, it is simply given as an input voltage without specifying the amount of modulation. Using a signal generator, signal-to-noise ratio is determined by measuring the receiver's output power level with and without an input signal. Output power with zero input is, of course, noise alone. Output power with a finite input signal is equal to the sum of the noise and the signal. Signal-to-noise ratio is then given by:

$$S/N = [10 \log (P_s/P_n) - 1]\,dB \qquad (1)$$

Where: P_s is the output power with signal applied and P_n is the output power with zero input.

For sensitivity measurements, noise is measured first, the required output signal level P_s is calculated, and the generator is adjusted to produce this output power. Sensitivity voltage is then read directly from the attenuator setting.

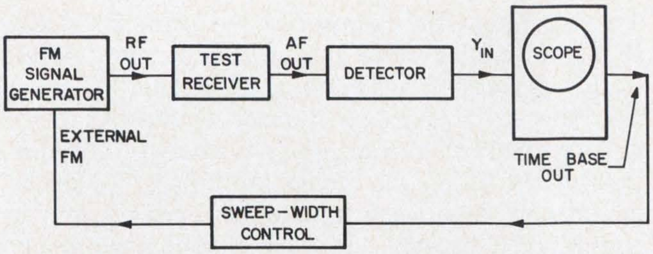
Using sweep frequency, noise level and signal plus noise are displayed simultaneously since the baseline of the response display corresponds not to zero output but to the noise level. At the comparatively high input voltages used for bandwidth measurement, the difference is negligible. However, if the input voltage is reduced to the specified sensitivity level, it is necessary to turn up the effective gain of the scope's vertical amplifier to obtain a display. At this gain setting, the height of the displayed baseline is easily measured.

It is necessary to first establish the position of zero vertical input deflection on the baseline of the scope's graticule. This is done by disconnecting the vertical input and bringing the trace to the graticule baseline with the position control. Noise level, when the scope is reconnected, is simply the distance between the graticule and display baselines. The distance between the graticule baseline and the peak of the displayed response is proportional to signal-plus-noise voltage.

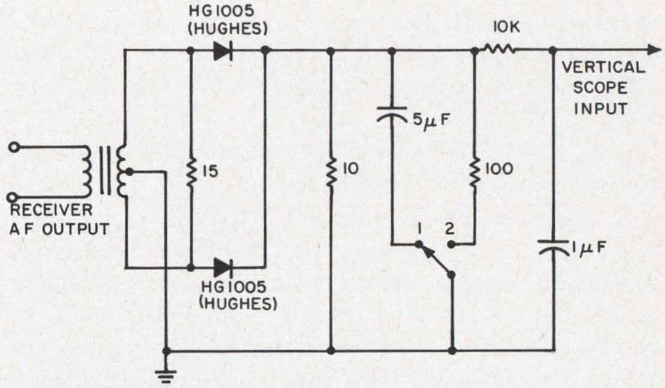
One minor point—signal-to-noise is essentially a power ratio, while scope deflection is proportional to peak voltage. This is true with the high levels used for frequency response measurement, but not necessarily true at the lower noise measurement signal levels. The answer lies in the detector used. Most diodes have transfer characteristics which are linear above 500 mV and approximate square-law responses below. Realizing this, it is easy to construct a detector with a voltage output nearly proportional to the mean power in its input circuit (See Fig. 2). The complete test set up for sensitivity measurement is shown in Fig. 3.

1. The generator is tuned and the sweep width adjusted to obtain a suitable display. The switch is

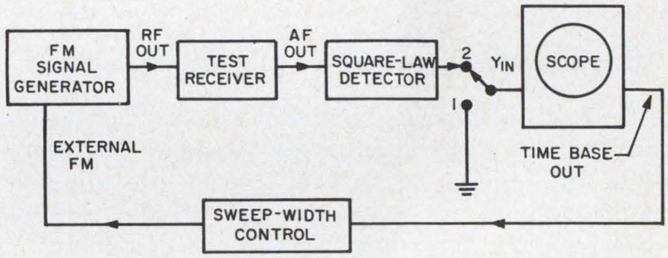
J. F. Golding, Group Leader, Marconi Instruments Ltd., St. Albans, Hertfordshire, England



1. **Conventional sweep generator-scope setup** for dynamic display of receiver frequency response.



2. **Full-wave detector** gives voltage output proportional to mean power applied to its input. With switch in position 1, the unit is a peak voltage detector; a flip of the switch converts it to a square-law device. The 15-Ω resistor is used only when necessary to terminate the receiver's AF output circuit.



3. **Sensitivity measurement setup** parallels basic frequency response setup with detector acting as a square-law device.

set to position 1 so that the scope has no vertical input and the trace then brought to the baseline.

2. The switch is then reset to position 2 and the AF gain of the receiver adjusted to bring the display baseline to the line on the dB scale corresponding to the specified signal-to-noise ratio.

3. The peak of the curve is brought to the 0-dB line with the generator's attenuator controls, which then indicate sensitivity.

This sequence is simpler and the possibility of the generator drifting out of tune is negligible.

Same set-up for AM receivers

If the generator has provisions for applying AM and frequency sweep simultaneously, the test set-up to Fig. 3 is equally suitable for a conventional double sideband AM receiver. The usual method of displaying the response characteristic using a sweep generator is by connecting the scope's vertical input directly to the receiver's detector. However, for audio bandwidths, the application of a frequency-swept amplitude-modulated test signal gives accurate results. The AM frequency must be low (about 10%) compared to the bandwidth, and the modulation depth should be restricted to about 20%. Then the displayed response using the basic swept set-up is the same as that obtained by dc coupling the scope to the receiver's detector.

Maximum sensitivity is the term usually applied to what is virtually a receiver gain measurement expressed in terms of RF input voltage for a given AF output power. The bandwidth of receivers normally measured is seldom a small enough fraction of the tuning frequency to warrant any precaution against generator frequency drift. Here, the case for sweep frequency rests upon the ability to conduct a number of tests with the same basic set-up. In order to give an absolute measure of output power, the detector must be calibrated with a monitored AF signal. Having established the scope deflection for the required AF power, the measurement is a simple matter of adjusting the input signal level to produce this deflection at the center frequency of the display. Maximum sensitivity measurements are normally made with 30% modulation at 400 Hz. Application of this modulation may cause slight deformation of the skirts of display, but there is negligible amplitude error in the region of the peak.

Aside from the fact that the noise-limited sensitivity of an AM receiver is usually measured with 30% modulation applied to the carrier, the method of measurement is very similar to that used for SSB and telegraphy receivers. There is one important difference.

The noise level of a SSB receiver remains constant with or without the input signal. If an AM receiver is tuned to an unmodulated RF signal which is below the agc threshold, the noise level rises noticeably as compared with the noise for zero input. Without an input signal, internally generated noise is not sufficient to drive the receiver's detector to the linear part of its characteristic. But, when an external carrier is applied, the noise voltages add to it and effectively produce random modulation which is linearly detected.

Signal-to-noise ratio is therefore always measured with the carrier applied throughout the test, at a level close to the specified sensitivity. Noise output power is first measured with the carrier unmodulated. Modulation is then applied and a second measurement made, giving the signal plus noise sum. The ratio is then calculated by the formula given for SSB receivers (Eq. 1).

Using sweep frequency, the sensitivity measurement can again be made in three simple steps, without calculation and with complete independence from frequency drift. The set-up is again that of Fig. 3.

1. Vertical deflection with zero input is first set to the graticule baseline as before.

2. The switch is then set to position 2 and a response curve displayed by sweeping the unmodulated RF signal through the receiver's IF passband. This curve is due to the noise output of the receiver; therefore the receiver's AF gain is set to bring its peak to the line on the dB graticule corresponding to the required signal-to-noise.

3. 30% AM is applied to the carrier at the specified AF and the generator's attenuator is adjusted to bring the peak of the displayed curve to the 0-dB line on the graticule. The attenuator reading is then the noise-limited sensitivity.

Narrow-band FM receivers tax generator stability

Vhf or uhf narrow-band FM receivers probably tax the frequency stability of the generator more than any other type. In fixed and mobile point-to-point systems, channel spacings of 25 kHz are quite common, maximum rated deviation being 15 kHz. Noise-limited sensitivity measurements are usually made at peak deviation of 30% of maximum (5 kHz) so that the signal generator needs to drift only about 6 kHz from center frequency before the outer significant sidebands fall outside the receiver's passband. At a tuning frequency of the order of 470 MHz this calls for a stability of about 0.00125% over the time necessary to make the measurement.

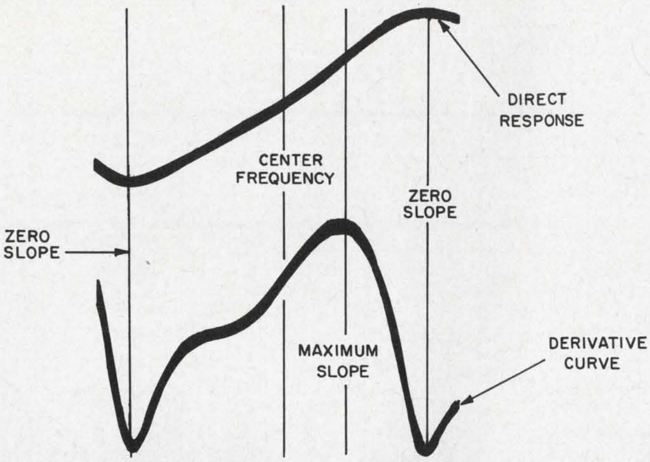
Because of the ready adaptability of many FM generators to sweep frequency methods, their use for the dynamic display of FM receiver characteristics is quite common. Display of the IF amplifier response requires a separate detector fed directly from the last IF stage, but otherwise, the method is similar to that used for any other type of receiver. The main application of the sweep generator to FM receivers, however, is for examination of demodulator characteristics. The dynamic display of demodulator response can be produced on a scope using any FM generator suitable for general receiver tests. However, maximum frequency deviation of the generator must be large enough to accommodate the entire demodulator response. Of receivers in common use, broadcast receivers, designed for 75-kHz maximum deviation, require the widest sweep (about ±100 kHz). To check the demodulator realistically, the test signal should be applied at full limiter voltage and it should also be derived from the correct source impedance. To obtain these conditions, use the IF amplifier of the receiver as the connecting network between the generator and the demodulator.

Then, the generator output is fed into the receiver's IF amplifier input or, into the antenna socket if this is more convenient. Care should be taken that the displayed demodulator characteristic is not modified by the frequency response characteristic of the receiver's tuned amplifiers. To do so, modulating frequency should be kept as low as conveniently possible (50 Hz under normal circumstances). The bandwidth of the receiver normally accommodates the multiple FM sidebands at much higher modulation frequencies, so all significant sidebands at 50-Hz spacing are easily handled.

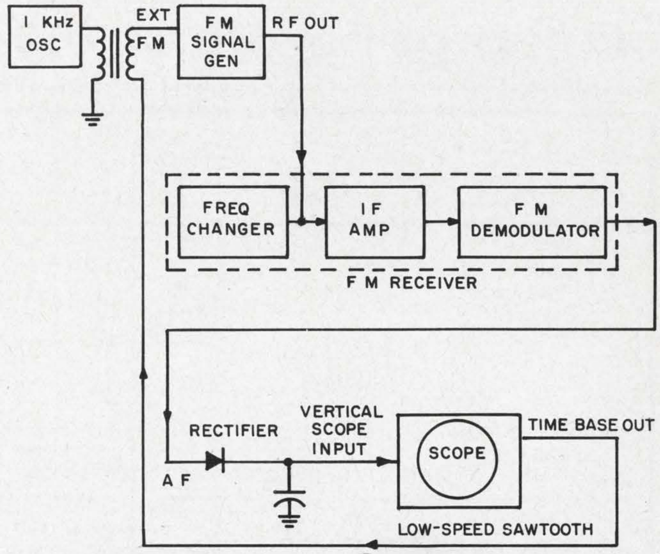
This usually necessitates modulating the generator from an external source, and, in this case, a sinewave is more convenient than a sawtooth. With sinewave modulation, the generator's modulation meter indicates the frequency deviation, which is half the sweep width. The horizontal deflection on the scope is obtained by also feeding the output of the modulating oscillator to the external time base terminal of the scope, and the total length of the trace then corresponds to twice the FM deviation as indicated on the modulation meter. Horizontal amplifier gain can then be adjusted so that the horizontal calibration of the scope's graticule becomes a frequency scale. The scope's vertical input is connected directly to the audio output terminal of the receiver's demodulator. The high input impedance of the scope is unlikely to affect demodulator operation. With the signal generator tuned to the IF (or RF) center frequency, sufficient output is applied to operate the limiter of the receiver. The familiar "S" shaped demodulator response will be displayed.

If the FM generator is suitable, a much more useful display can be produced using two superimposed modulating frequencies. When the object of the display is measurement of true demodulator linearity over the nominally linear part of its characteristic, more information can be gained from a display of the derivative of the demodulation curve. This is a display in which the instantaneous vertical position of the spot is proportional to the instantaneous slope of the demodulation curve. Such a display gives far better discrimination than the direct response curve (see Fig. 4).

The test set-up is shown in Fig. 5. A slow sawtooth voltage or low-frequency sinewave (about 60-Hz) is simultaneously applied to the generator's external modulation terminals and the horizontal deflection system of the scope. The amplitude of this sweep voltage should be such as to give a frequency sweep which completely accommodates the demodulator characteristic. Its frequency should be below the low-frequency response of the receiver's audio amplifier. Superimposed upon this voltage, by means of the transformer, is an AF voltage (say 1 kHz) of sufficient



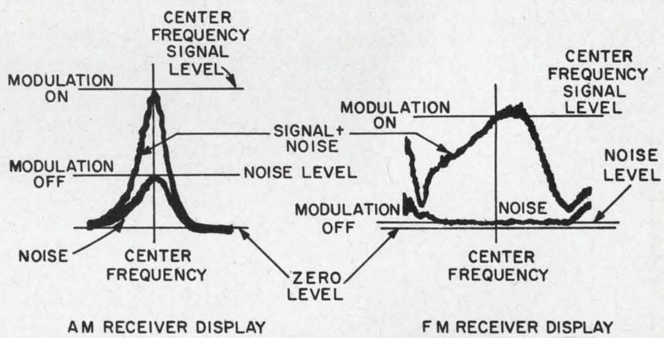
4. **Derivative of FM demodulator response** (bottom curve) shows changes in slope much more markedly than direct response (upper curve).



5. **Test setup for demodulator derivative curve.** For sensitivity measurement, the generator's RF output is applied to the receiver's antenna input.

amplitude to give about 1% of maximum rated deviation. The vertical input terminal of the scope is connected via a detector to the AF output of the receiver. Thus, both the gain and the low-frequency output of the audio amplifier are utilized. The instantaneous 1-kHz receiver output is then directly proportional to the slope of the demodulation curve at the instantaneous input carrier frequency, so that the spot traces out the derivative curve. Any nonlinearity is easily detected by aligning the curve with one of the horizontal graticule lines on the scope. Also, the relative magnitude of the nonlinearity can be measured by comparing the amplitude of the departure from this line with the mean height of the display from the zero points.

The procedure for making signal-to-noise measurements using sweep frequency parallels the static method. With true zero established at the graticule baseline, a modulated signal is applied to the receiver (the low-voltage AF modulating voltage is superimposed on the sweep voltage). Most specs quote noise-limited sensitivity with FM applied at 30% of the maximum rated deviation. This FM level naturally distorts the edges of the derivative curve, but this is unimportant because the height of the displayed curve at the center frequency remains proportional to the in-tune output of the receiver. Then, with the modulated RF input level approximately at the specified sensitivity level, the AF gain of the receiver is adjusted to bring the peak of the "modulation on" curve to the 0-dB line on the graticule. The modulation voltage is then switched off so that the scope displays a curve representing noise level as a function of RF input frequency. Because the application of an RF input reduces the receiver noise output, this second curve is inverted as shown in Fig. 6 with the trough indicating the in-tune noise level. The RF output of the generator is adjusted to bring the lowest point on the displayed curve into coincidence with the dB graticule line corresponding to the specified signal-to-noise ratio. Noise-limited sensitivity is then read from the generator's attenuator dials.



6. **Modulation on/modulation off displays** for AM (left) and FM (right) receiver noise-limited sensitivity. Trough in FM display indicates in-tune noise level.

Accurate tuning is essential for signal-to-noise measurement on an FM receiver because part of the AM rejection takes place in the demodulator itself. When the measurement is made with sweep frequency, this aspect is dealt with automatically.

Consider the effect of sweep speed

For all of the tests, the most important general rule to be remembered is the relation between sweep speed and bandwidth. For measurements which are not concerned with the true shape of the frequency response characteristic, it is tempting to increase sweep speed and ignore the effects of ringing in the receiver's amplifier. This can lead to amplitude error and should be avoided. As a rule of thumb to establish maximum permissible sweep speed, there is no significant deformation if the highest frequency component of the displayed response is less than 1% of the receiver's 3-dB bandwidth. ■ ■

Sweep generators .004-112 MHz

For information on how to use these tables, turn to page 2

	Manufacturer	Model	FREQUENCY Min. kHz	FREQUENCY Max. MHz	SWEEP WIDTH Min. kHz	SWEEP WIDTH Max. MHz	SWEEP WIDTH Rate Hz	OUTPUT Volts	OUTPUT Imp. Ohms	Type	Price $	Notes
SW-1	ITT	74217-A	.03	.004	ina	ina	ina	-20 dBm	600	C	2550	
	AMI	321	1	.005	.05	0.2 kHz	.03-1 sec	1	600	C	2975	
	LTV Ling	CO-10-A	.005	.005	note 8	note 8	note 9	0.1-1	ina	R	1360	
	Probescope	5	0	.005	.02	0.6	1-30 sec	1	ina	R	475	
	Spectral Dynamics	SD-104-5	.005 Hz	.05	.005 Hz	.05	0-1000	1	600	R	1965	
	LTV Ling	CO-10-B	.01	.01	note 8	note 8	note 9	0.1-1	ina	R	1360	
	Spectral Dynamics	SD-104-1	.01 Hz	.01	.01 Hz	.01	0-200	1	600	R	1975	
	Clough-Brengle	182-A	.025	.015	0	full rng	5	0.1 W	600,20k	C,R	185	
	Waveforms	610B	.02	.02	ina	ina	6-60 sec	2.5	600	C,R	1000	a
	Telonic	LA-1M/SM-2000	.02	.02	.05	.02	.01-100	17	600	C,R	1770	a,f
SW-2	H-P	207A	.02	.02	note 18	note 18	note 18	10	600	C,R	425	
	Spectral Dynamics	SD-104-2	.02 Hz	.02	.02 Hz	.02	0-1000	1	600	R	1965	
	Clough-Brengle	282-A	.025	.032	0.5	.01	2-10	0.1 W	600,4k	C,R	485	
	Clough-Brengle	610-A	.025	.046	0	.02	2-10 sec	0.1 W	4000	C,R	485	
	Probescope	100	0	0.1	0.2	.02	1 sec	10	ina	R	425	
	Kay	141	.02	0.2	0	full rng	0.2-30	5	600	C,R	1295	a,e
	Kay	P141A	.02	0.2	0	.02	0.2-30	1	50	C,R	475[12]	a,e
	Probescope	500	0	0.5	2	0.2	0.33 sec	10	ina	R	450	
	Kay	P142	.035	0.6	0	.04	0.2-30	1	50	C,R	475[12]	a,e
	Telonic	L-1/SM-2000	400	1.8	0.1%	40%	.01-100	1	50	C,R	1075	a,f
SW-3	Kay	P130	0.1	2	0	full rng	0.2-30	1	50	C,R	375[12]	a,e
	Telonic	L-2/SM-2000	1000	4	0.1%	full rng	.01-100	1	50	C,R	1075	a,f
	Tel-Inst	1902A	4500	4.5	note 7	note 7	2000	0.75	75	C	480	b
	Tel-Inst	1105	50	10	0	full rng	60	2	75	C,R	880	a,d
	Telonic	HD-4	10	10	25	10	50/60	1	50,75	C,R	745	
	Telonic	SV-14	10,200	11.2	150	full rng	50/60	3.5μV-1	75	C	850	
	R & S	SWH	50	12	.05%	5%	20	50μV-2	60	C	1440	
	Telonic	VR-2M/SM-2000	0.2	12	0.1	10	.01-100	1	50	C,R	1725	a,f
	Jerrold	1015	1	15	0	full rng	.007-60	2.236	50,75	C,R	2540	
	Telonic	L-3/SM-2000	4000	16	0.1%	75%	.01-100	1	50	C,R	1075	a,f
SW-4	Telonic	1001	100	20	10	20	.01-60	1	50	C,R	request	e
	Marconi	TF-1099	100	20	0	full rng	50-60	0.3-3	75	C,R	1265	
	Kay	150B	50	20	0	full rng	60	0.2	70	C,R	595	a,e
	R & S	SWOF	20	20	1000	16	0.2-20	.001-1	75	C	6600	
	Kay	P152	10	20	0.5	20	0.2-30	1	50	C,R	375[12]	a,e
	Texscan	VS-20	0.2	25	0	full rng	5-60	1	50	C,R	850	c
	Kay	P855	2000	32	0	2%	0.2-30	1	50	C,R	1075	a,e
	Telonic	L-4/SM-2000	10,000	40	0.1%	80%	.01-100	1	50	C,R	595[12]	a,f
	Kay	370A	20,000	50	ina	note 13	60	0.25	70	C	495	a,e
	Jerrold	H-73/707C	2000	50	±0.5%	±60%	.007-60	20 dBm	50	C,R	840	e,f
SW-5	RCA	WR-69A	50	50	0	20	60	0.1	100	C	295	
	Kay	380A	20,000	60	3000	20	60	0.25	70	C,R	450	a,e
	Clough-Brengle	603	20,000	60	0	12	60	0.1	75	C	250	a,b
	Tel-Inst	1500B	400	70	0	full rng	ina	1	75	C	595	
	Telonic	L-5/SM-2000	20,000	75	0.1%	40%	.01-100	1	50	C,R	1075	a,f
	Telonic	LD-5	20,000	75	.05%	40%	50/60	1μV-1	50	C,R	695	
	Telonic	SSX-2	20,000	75	0.1%	40%	60	1	50	C,R	1695	a
	Telonic	HD-7	100	75	100	50	50/60	1	50,75	C,R	695	
	Kay	386AR	455	98	60	24	ina	0.2	50	C,R	1250	d
	Texscan	HS-70	20,000	100	0.1%	15%	50/60	4 W	ina	C,R	2500	c
SW-6	Telonic	PD-2	20,000	100	0.2%	10%	50/60	14	50	C,R	2500	a
	Jerrold	H-71/707C	10,000	100	±0.5%	±60%	.007-60	20 dBm	50	C,R	840	e,f
	Texscan	VS-30	100	100	0	full rng	5-60	1	50	C,R	850	c
	Wiltron	610	100	100	0	full rng	.01-10 sec	1	50	C,R	1975	a
	Kay	154A	50	100	0	full rng	5-60	1	50	C,R	895	e
	Heath	FMO-1	90,000	107	200	1	60	0.5	50	C	35 kit	
	Telonic	SV-14	86,000	110	4000	full rng	50/60	3.5μV-1	75	C	850	
	Telonic	LH-2/SM-2000	400	110	40	40	.01-100	0.25	50	C,R	1275	a,f
	H-P	3211A	100	110	0	full rng	10-100	0.7	50	C,R	1000	
	Jerrold	602-5B	4000	112	±1%	±60%	50-60	2.5	50,75	C,R	475	f

Notes, abbreviations and manufacturers' index at end of this section.

Sweep generators 115-950 MHz

	Manufacturer	Model	FREQUENCY Min. kHz	FREQUENCY Max. MHz	SWEEP WIDTH Min. kHz	SWEEP WIDTH Max. MHz	SWEEP WIDTH Rate Hz	OUTPUT Volts	OUTPUT Imp. Ohms	Type	Price $	Notes
SW-7	Kay	P154	.05	115	0	100	0-30	1	50	C,R	495[12]	a,e
	Kay	866A	4	120	ina	30	60	1	70	C,R	950	a,d,e
	AMI	301	.01	120	0	3	ina	ina	ina	C,R	3000	
	Telonic	L-6/SM-2000	50	125	0.1%	30%	.01-100	1	50	C,R	1075	a,f
	Kay	865A	10	135	ina	30	60	1	70	C,R	950	a,d,e
	Kay	932B	0.1	150	note 14	note 14	60	0.25, 1	70	C,R	825	a,d,e
	Hickok	288AX	.035	160	0	0.45	60	ina	100	C	315	
	Jerrold	H-72/707C	20	200	±0.5%	±60%	.007-60	13 dBm	50	C,R	840	e,f
	Telonic	HD-3	1	200	200	full rng	50/60	0.25	50,75	C,R	835	
	Telonic	L-7/SM-2000	100	210	0.1%	25%	.01-100	0.75	50	C,R	1075	a,f
SW-8	Prec Apparatus	E410C	3	213	0	30	60	0.1	50	R	160	
	Kay	932A	0.1	215	note 15	note 15	60	0.25, 1	70	C,R	825	a,e
	Tel-Inst	1212	54	216	10,000	15	ina	0.5	75,300	C	950	a
	Kay	361C	43.5	216	15,000	ina	60	1	70	C,R	845	a,e
	EICO	368	3	216	0	30	60	0.1	50	C	120	a,b
	Jerrold	H-75/707C	45	220	±0.5%	±60%	.007-60	13 dBm	50	C,R	890	e,f
	AMI	320	4	220	0	3	ina	1 μV-0.1	50	C	485	a,b
	Heath	IG-52	3.6	220	0	42	60	.08-0.23	50	C	68	a,b
	EICO	369	3	220	0	20	60	0.1	50	C	150	a,b
	Kay	P860	2	220	10	30	0.2-30	1	50	C,R	445[12]	a,e
SW-9	GE	ST-4A	0.1	220	500	15	ina	0.5	20-70	C,R	request	a
	Kay	935B	50 Hz	220	20	60%	0.2-30	1	70	C,R	1295	e
	Telonic	SV-13	20	225	note 3	note 3	50/60	1	50,60,75	C	833	a
	Jerrold	601-5B	12	225	±1%	±60%	50-60	0.5	50,75	C,R	450	
	R & S	SWF	5	225	.05	15	60	0.1mV-0.1	60	C	1400	
	Hickok	615	0	225	0	15	60	ina	90	C	360	
	EICO	360	0.5	228	0	30	60	ina	ina	C	50	b
	Telonic	3001/SM-2000	50	230	2000	180	.01-100	1	50	C,R	1570	f
	Texscan	TH-200	1	230	100	230	50/60	0.25	50	C	525	c
	Gen Radio	1025-A	0.7	230	0	full rng	20	0.3 μV-1	50	C,R	3450	
SW-10	Texscan	HS-75	100	250	0.1%	15%	50/60	4 W	ina	C,R	2500	c
	Telonic	PD-3	100	250	0.2%	15%	50/60	14	50	C,R	2500	a
	Kay	385A	1	260	70	70	60	0.5	70	C,R	725	a,e
	Kay	159B	1	300	50	full rng	5-60	0.5	50	C,R	895	e
	Jerrold	SS-300	0.5	300	200	300	.003-60	0.6	50	C,R	1095	a,c,e
	Texscan	VS-40	0.5	300	200	300	5-60	0.5	50	C,R	850	c
	Kay	386AN	6.975	332.15	note 16	note 16	ina	0.5	70	C,R	1220	a,d,e
	Kay	386	1	350	60%	70%	60	0.5	50,70	C,R	925	a,e
	Telonic	PD-7	200	375	0.2%	10%	50/60	14	50	C,R	2500	a,c
	Micro-Power	H24MD/220	200	400	0	full rng	.01-100 sec	.02 W	ina	C	3650	f
SW-11	EPSCO	SG-132-A	15	400	0.1%	±20%	25	0.15	50	C	2440	
	R & S	SWOB I	0.5	400	200	50	60	0.4	50,75	C	3100	
	Texscan	HS-80	200	425	0.1%	15%	50/60	4 W	ina	C,R	2500	c
	Telonic	SH-1/SM-2000	0.5	460	200	200	50/60	0.35	50	C,R	1175	a,f
	Kay	P867	220	470	20	30	0.2-30	0.5	50	C,R	200[12]	a,e
	Kruse-Storke	5009/5000	250	500	0	full rng	.01-100 sec	.02 W	ina	C,R	2740	a,b,c,f
	Servo	Q880	250	500	0	full rng	.01-100	0.4 W	ina	C,R	3400	a
	Micro-Power	H25MD/220	250	500	0	full rng	.01-100 sec	.05 W	ina	C	3550	f
	Telonic	S-4/SM-2000	150	500	.02%	10%	50/60	1	50	C,R	1125	a,f
	Micro-Power	H37MD/220	350	700	0	full rng	.01-100 sec	0.1 W	ina	C	3650	f
SW-12	Grundig	WS-3	4	800	0	30	50	0.5	60	C	595	
	Blonder-Tongue	4122	10	890	5000	420	60	0.5	75	C	request	a
	Blonder-Tongue	4114	5	890	5000	420	60	0.1	75	C	request	a
	Tel-Inst	1211	450	900	50,000	50	ina	1	75	C	1100	a
	Telonic	HD-1A	1	900	200	200	60	0.75	50	C,R	995	a
	Telonic	S-5/SM-2000	460	920	.02%	10%	50/60	1	50	C,R	1125	a,f
	Texscan	CS-77	460	920	460 MHz	460	50/60	0.5	50	C	440	c
	Texscan	CS-76A	460	920	100	45	50/60	0.5	50	C	525	c
	Telonic	SD-3	440	920	.02%	10%	60	0.75	50	C,R	745	a
	Kay	111	10	950	50	40	60	0.15	70	C,R	625	a,e

Notes, abbreviations and manufacturers' index at end of this section.

Sweep generators 950-4000 MHz

	Manufacturer	Model	FREQUENCY Min. MHz	FREQUENCY Max. MHz	SWEEP WIDTH Min. kHz	SWEEP WIDTH Max. MHz	SWEEP WIDTH Rate Sec	OUTPUT Watts	OUTPUT Imp. Ohms	Type	Price $	Notes
SW-13	Kay	110	.05	950	50	40	60 Hz	0.5V	50	C,R	625	a,e
	Telonic	3005/SM-2000	460	960	5000	500	.01-100 Hz	0.3V	50	C,R	1525	f
	Kay	1483A	440	960	5000	520	10-30 Hz	0.5V	50	C,R	495	
	Kruse-Storke	5010/5000	500	1000	0	full rng	.01-100	.02	ina	C,R	2740	a,b,c,f
	Servo	P880	500	1000	0	full rng	.01-100 Hz	0.4	ina	C,R	3400	a
	Micro-Power	H51MD/220	500	1000	0	full rng	.01-100	0.1	ina	C	3550	f
	Telonic	VR-50M/SM-2000	500	1000	5000	500	.01-100 Hz	0.3V	50	C,R	1725	f
	Texscan	HS-85	400	1000	0.1%	15%	50/60 Hz	4	ina	C,R	2500	c
	Telonic	PD-8	375	1000	0.2%	15%	50/60 Hz	14V	50	C,R	2500	a
	Texscan	VS-70	275	1000	50	40%	5-60 Hz	0.5V	50	C,R	940	c
SW-14	Kay	P123	100	1000	0.2%	full rng	ina	0.5V	50	C,R	375(17)	
	Kay	100	.05	1000	50	40	60 Hz	0.5V	50	C,R	575	a,e
	Kay	P121/121	0.5	1050	50	350	10-60 Hz	0.5V	50	C,R	1390	f
	Jerrold	890	0.5	1100	100	200	60 Hz	0.25V	50,75	C,R	845	a,b
	Telonic	S-6/SM-2000	600	1200	.02%	8%	50/60 Hz	0.75V	50	C,R	1125	a,f
	R & S	SWLU	400	1200	0	170	60 Hz	3V	50,60	C	1690	
	Micro-Power	H41MD/220	400	1200	0	full rng	.01-100	.02	ina	C	4050	f
	Jerrold	900-C	0.5	1200	10	1	60 Hz	0.25V	50	C,R	2180	a,b
	Jerrold	900-A	0.5	1200	500	400	60 Hz	0.25V	50	C,R	1260	a,b
	Texscan	VS-80	0.5	1200	50	300	5-60 Hz	0.5V	50	C,R	1495	c
SW-15	R & S	SWOB II	0.5	1200	200	50	60 Hz	0.4V	50,75	C	4200	
	Kay	P122/121	900	1300	200	full rng	10-60 Hz	0.5V	50	C,R	1270	e,f
	Kay	P124/121	1300	1700	500	full rng	10-60 Hz	0.5V	50	C,R	1290	a,e
	Kay	121	0.5	1700	50	500	10-60 Hz	0.5V	50	C,R	895	a,e
	Telonic	E-1/SM-2000	460	1840	.02%	10%	50/60 Hz	0.25-1V	50	C,R	1575	a,f
	Alfred	651/650	1000	2000	0	full rng	.01-100	.08(6)	50	C,R	3350	c
	Alfred	651K/650	1000	2000	0	full rng	.01-100	.07(6)	50	C,R	3600	c,f
	Alfred	651AK/650	1000	2000	0	full rng	.01-100	.06(5)	50	C,R	3850	c,f
	Alfred	631A	1000	2000	0	full rng	.01-100	.05	ina	C,R	3490	c
	Alfred	631D	1000	2000	0	full rng	.01-100	.02	50	C,R	3750	c
SW-16	Alfred	641	1000	2000	0	full rng	.01-100	.08(2)	50	C,R	3050	c
	Alfred	641K	1000	2000	0	full rng	.01-100	.07(4)	50	C,R	3325	c
	Alfred	6021	1000	2000	0	full rng	.01-100	1	50	C	6350	a
	E-H	571	1000	2000	0	full rng	note 1	0.12	50	R	3660	
	H-P	8691A/8690A	1000	2000	0	full rng	.01-100	0.1	50	C,R	3450	f
	H-P	8691B/8690A	1000	2000	0	full rng	.01-100	.07	50	C,R	3750	f
	Kruse-Storke	5011/5000	1000	2000	0	full rng	.01-100	.01	ina	C,R	3080	a,b,c,f
	LFE	832-L-1	1000	2000	1000	full rng	.01-100	.08-0.15	50	C,R	request	
	Micro-Power	H102L/220	1000	2000	0	full rng	.01-100	0.1	ina	C	3750	f
	MSI	N900L	1000	2000	0	full rng	ina	0.1	50	R	1995	
SW-17	R & S	SMC	1000	2000	0	full rng	10 Hz	25-30 dBm	50	C	9600	
	Servo	L880	1000	2000	0	full rng	.01-100 Hz	0.1	ina	C,R	3190	a
	Texscan	VS-120	1000	2300	50	25%	5-60 Hz	0.5V	50	C,R	1695	c
	Kruse-Storke	5012/5000	1400	2400	0	full rng	.01-100	.005	ina	C,R	3080	a,b,c,f
	Telonic	E-2/SM-2000	600	2400	.02%	10%	50/60 Hz	0.25-1V	50	C,R	1770	a,f
	Alfred	631A-S1	1400	2500	0	full rng	.01-100	.05	50	C,R	3790	a,c
	Alfred	631D-S1	1400	2500	0	full rng	.01-100	.07	50	C,R	3990	a,c
	Alfred	641K-S1	1400	2500	0	full rng	.01-100	.07(4)	50	C,R	3600	c
	Alfred	641-S1	1400	2500	0	full rng	.01-100	.08(2)	50	C,R	3300	c
	Alfred	651A-S1/650	1400	2500	0	full rng	.01-100	.06(5)	50	C,R	3875	c,f
SW-18	Alfred	651AK-S1/650	1400	2500	0	full rng	.01-100	.06(5)	50	C,R	4175	c,f
	Alfred	651K-S1/650	1400	2500	0	full rng	.01-100	.07(6)	50	C,R	3900	c,f
	Alfred	651-S1/650	1400	2500	0	full rng	.01-100	.08(6)	50	C,R	3600	c,f
	Micro-Power	H142L/220	1400	2500	0	full rng	.01-100	0.1	ina	C	4050	f
	Telonic	E-3/SM-2000	550	3000	.02%	8%	50/60 Hz	0.2-0.75V	50	C,R	1770	a,f
	R & S	SMC	1600	3200	0	full rng	10 Hz	22-30 dBm	50	C	9000	
	Alfred	632D	2000	4000	0	full rng	.01-100	.02	50	C,R	3490	a,c
	Alfred	632A	2000	4000	0	full rng	.01-100	.04	ina	C,R	3290	a
	Alfred	652AK/650	2000	4000	0	full rng	.01-100	.04(5)	50	C,R	3680	c,f
	Alfred	652A/650	2000	4000	0	full rng	.01-100	.04(5)	50	C,R	3400	c,f

Notes, abbreviations and manufacturers' index at end of this section.

Sweep generators 4000-8300 MHz

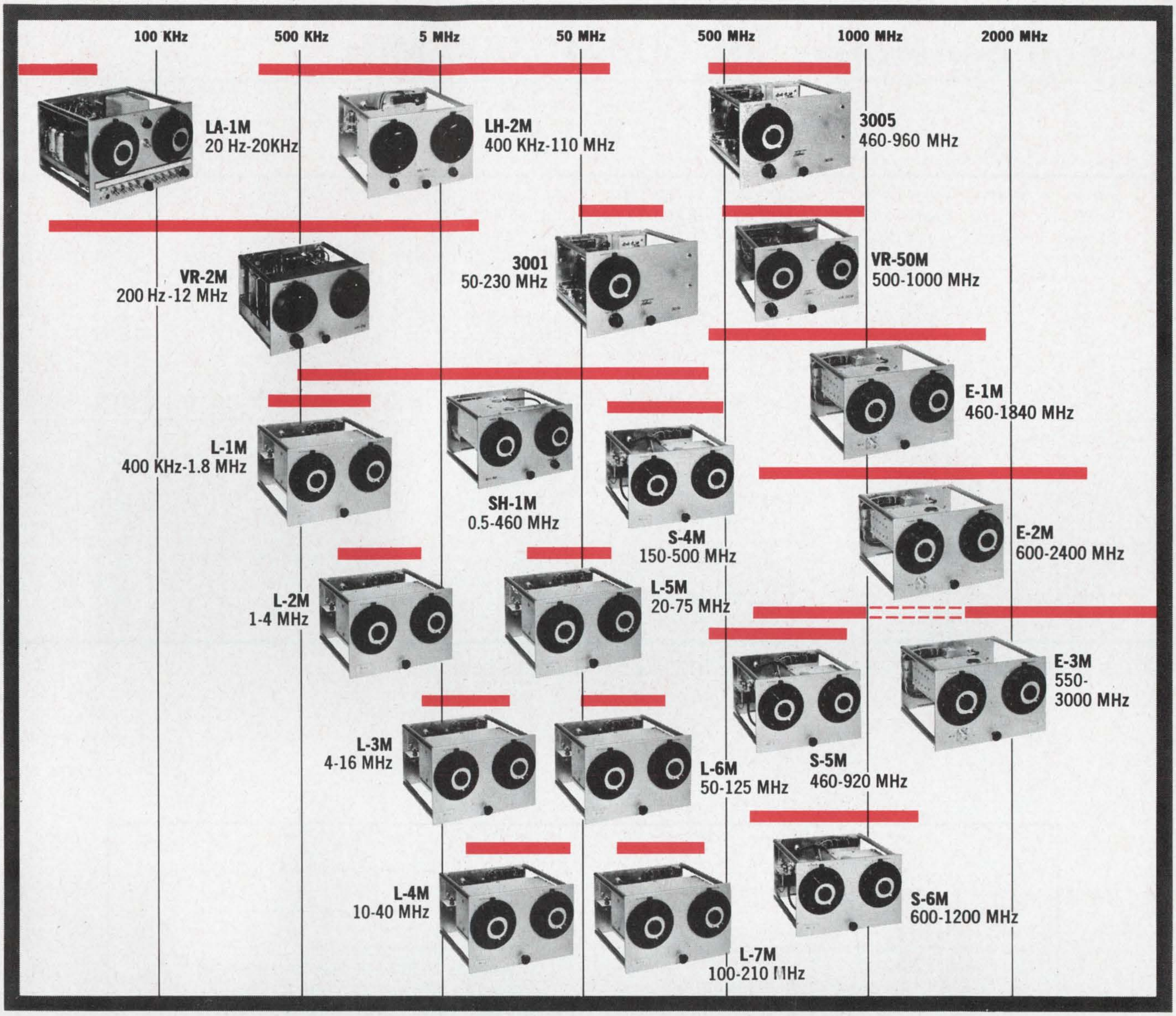
			FREQUENCY		SWEEP WIDTH			OUTPUT				
	Manufacturer	Model	Min. MHz	Max. MHz	Min. kHz	Max. MHz	Rate Sec	Watts	Imp. Ohms	Type	Price $	Notes
SW-19	Alfred	652K/650	2000	4000	0	full rng	.01-100	.05(6)	50	C,R	3425	c,f
	Alfred	642K	2000	4000	0	full rng	.01-100	.05(4)	50	C,R	3140	c
	Alfred	642	2000	4000	0	full rng	.01-100	.06(2)	50	C,R	2850	c
	Alfred	652/650	2000	4000	0	full rng	.01-100	.06(6)	50	C,R	3150	c,f
	Alfred	6022	2000	4000	0	full rng	.01-100	1	50	C	6890	a
	E-H	572	2000	4000	0	full rng	note 1	.09	50	R	3460	
	H-P	8692B/8690A	2000	4000	0	full rng	.01-100	.04	50	C,R	3550	f
	H-P	8692A/8690A	2000	4000	0	full rng	.01-100	.07	50	C,R	3250	f
	LFE	832-S-1	2000	4000	1 MHz	full rng	.01-100	.04-0.15	50	C,R	request	
	MSI	N900S	2000	4000	0	full rng	ina	0.1	50	R	1995	
SW-20	Micro-Power	H204L/220	2000	4000	0	full rng	.01-100	.08	ina	C	3550	f
	Narda	64S2	2000	4000	0	full rng	.01-100	.048	ina	C,R	3250	
	Narda	64S1	2000	4000	0	full rng	.01-100	.05	ina	C,R	2750	
	Servo	S880	2000	4000	0	full rng	.01-100 Hz	.07	ina	C,R	2990	a
	Weinschel	S775A	2000	4000	0.2 MHz	full rng	note 19	.07	50	C,R	2750	
	Alfred	652K-S5/650	1700	4200	0	full rng	.01-100	.03(5)	ina	C,R	3825	c,f
	Alfred	642K-S1	1700	4200	0	full rng	.01-100	.03	ina	C,R	3150	a,c
	Alfred	652-S5/650	1700	4200	0	full rng	.01-100	.035(6)	ina	C,R	3475	c,f
	Alfred	642-S1	1700	4200	0	full rng	.01-100	.035	ina	C,R	3300	a,c
	Alfred	652A-S5/650	1700	4200	0	full rng	.01-100	.015(6)	ina	C,R	3700	c,f
SW-21	Alfred	652AK-S5/650	1700	4200	0	full rng	.01-100	.015(5)	ina	C,R	4075	c,f
	H-P	H01-8692B/8690A	1700	4200	0	full rng	.01-100	.015	50	C,R	3850	f
	Micro-Power	H204LA/220	1700	4200	0	full rng	.01-100	.03	ina	C	3850	f
	Servo	R880	1700	4200	0	full rng	.01-100 Hz	.02	ina	C,R	3290	a
	R & S	SMC	2400	4700	0	full rng	10 Hz	20-30 dBm	50	C	9000	
	Servo	T880	2400	5300	0	full rng	.01-100 Hz	.05	ina	C,R	3250	a
	Polarad	1307	5500	6600	0	40	50-60 Hz	note 10	50	C,R	2650	c
	Polarad	1307-P	5500(11)	6600	0	40	50-60 Hz	note 10	50	C,R	2800	c
	Alfred	633A-S1	3500	6750	0	full rng	.01-100	.01	50	C,R	3850	a,c
	Alfred	653A-S1/650	3500	6750	0	full rng	.01-100	.02(5)	50	C,R	3750	c,f
SW-22	Alfred	653AK-S1/650	3500	6750	0	full rng	.01-100	.02(5)	50	C,R	4250	c,f
	Alfred	643K-S1	3500	6750	0	full rng	.01-100	.03(4)	50	C,R	3800	c
	Alfred	653K-S1/650	3500	6750	0	full rng	.01-100	.03(6)	50	C,R	4050	c,f
	Alfred	653-S1/650	3500	6750	0	full rng	.01-100	.04(6)	50	C,R	3540	c,f
	Alfred	643-S1	3500	6750	0	full rng	.01-100	.04(2)	50	C,R	3290	c
	Alfred	633D-S1	3500	6750	0	full rng	.01-100	.008	50	C,R	4100	a,c
	Micro-Power	H356L/220	3500	6750	0	full rng	.01-100	.04	ina	C	4000	f
	R & S	SMC	3600	7100	0	full rng	10 Hz	15-25 dBm	50	C	9000	
	Polarad	1307-1	5200	7200	0	40	50-60 Hz	note 10	50	C,R	2300	c
	Polarad	1307-1P	5200(11)	7200	0	40	50-60 Hz	note 10	50	C,R	2450	c
SW-23	Polarad	1308	7100	7800	0	40	50-60 Hz	note 10	50	C,R	2650	c
	Polarad	1308-P	7100(11)	7800	0	40	50-60 Hz	note 10	50	C,R	2800	c
	Alfred	633A	4000	8000	0	full rng	.01-100	.02	ina	C,R	3390	a
	Alfred	653A/650	4000	8000	0	full rng	.01-100	.02(5)	50	C,R	3350	c,f
	Alfred	653AK/650	4000	8000	0	full rng	.01-100	.02(5)	50	C,R	3700	c,f
	Alfred	643K	4000	8000	0	full rng	.01-100	.025(4)	50	C,R	3230	c
	Alfred	653K/650	4000	8000	0	full rng	.01-100	.025(6)	50	C,R	3450	c,f
	Alfred	643	4000	8000	0	full rng	.01-100	.03(4)	50	C,R	2850	c
	Alfred	653/650	4000	8000	0	full rng	.01-100	.03(6)	50	C,R	3100	c,f
	Alfred	6023	4000	8000	0	full rng	.01-100	0.5	50	C	6990	a
SW-24	Alfred	633D	4000	8000	0	full rng	.01-100	.008	50	C,R	3650	c
	E-H	573	4000	8000	0	full rng	note 1	.035	50	R	3460	
	H-P	8693A/8690A	4000	8000	0	full rng	.01-100	.03	50	C,R	3125	f
	H-P	8693B/8690A	4000	8000	0	full rng	.01-100	.015	50	C,R	3450	f
	LFE	832-C-1	4000	8000	1 MHz	full rng	.01-100	.02-0.15	50	C,R	request	
	MSI	N900C	4000	8000	0	full rng	ina	.025	50	R	1995	
	Micro-Power	H408L/220	4000	8000	0	full rng	.01-100	.03	ina	C,R	3550	f
	Servo	C880	4000	8000	0	full rng	.01-100 Hz	.02	ina	C,R	2975	a
	Weinschel	C775A	4000	8000	0.2MHz	full rng	note 20	.02	50	C,R	2800	
	Alfred	653A-S2/650	3700	8300	0	full rng	.01-100	.005(6)	ina	C,R	3650	c,f

Notes, abbreviations and manufacturers' index at end of this section.

Sweep generators 8300-18,000 MHz

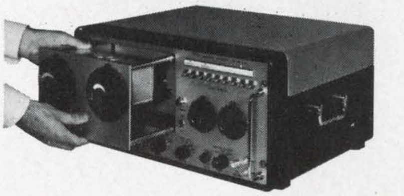
	Manufacturer	Model	FREQUENCY Min. MHz	Max. MHz	SWEEP WIDTH Min. kHz	Max. MHz	Rate Sec	OUTPUT Watts	Imp. Ohms	Type	Price $	Notes
SW-25	Alfred	653AK-S2/650	3700	8300	0	full rng	.01-100	.005(5)	ina	C,R	4000	c,f
	Alfred	643-S2	3700	8300	0	full rng	.01-100	.01(2)	ina	C,R	3150	a,c
	Alfred	643K-S2	3700	8300	0	full rng	.01-100	.01(4)	ina	C,R	3530	a,c
	Alfred	653-S2/650	3700	8300	0	full rng	.01-100	.01(6)	ina	C,R	3400	c,f
	Alfred	653K-S2/650	3700	8300	0	full rng	.01-100	.01(5)	ina	C,R	3775	c,f
	H-P	H01-8693B/8690A	3700	8300	0	full rng	.01-100	.005	50	C,R	3750	f
	Micro-Power	H408LA/220	3700	8300	0	full rng	.01-100	.015	ina	C	3900	f
	Servo	W880	3700	8300	0	full rng	.01-100 Hz	.005	ina	C,R	3275	a
	Polarad	1308-1	7100	8500	0	40	50-60 Hz	note 10	50	C,R	2450	c
	Polarad	1308-1P	7100(11)	8500	0	40	50-60 Hz	note 10	50	C,R	2600	c
SW-26	R & S	SMC	4800	9600	0	full rng	10	15-25 dBm	50	C	9000	
	Servo	J880	5300	10,000	0	full rng	.01-100 Hz	.01	ina	C,R	3450	a
	Alfred	634A	7000	11,000	0	full rng	.01-100	.006	ina	C,R	3650	c
	Alfred	654A/650	7000	11,000	0	full rng	.01-100	.01(6)	50	C,R	3450	c,f
	Alfred	654AK/650	7000	11,000	0	full rng	.01-100	.01(5)	50	C,R	3850	c,f
	Alfred	644K	7000	11,000	0	full rng	.01-100	.015(4)	50	C,R	3300	c
	Alfred	654K/650	7000	11,000	0	full rng	.01-100	.015(6)	50	C,R	3425	c,f
	Alfred	644	7000	11,000	0	full rng	.01-100	.02(2)	50	C,R	2900	c
	Alfred	654/650	7000	11,000	0	full rng	.01-100	.02(6)	50	C,R	3150	c,f
	Alfred	6024	7000	11,000	0	full rng	.01-100	1	50	C	7950	a
SW-27	H-P	H02-8694A/8690A	7000	11,000	0	full rng	.01-100	.025	50	C,R	request	f
	H-P	H02-8694B/8690A	7000	11,000	0	full rng	.01-100	.015	50	C,R	3500	f
	MSI	N900H	7000	11,000	0	full rng	ina	.025	50	R	1995	
	Micro-Power	H711L/220	7000	11,000	0	full rng	.01-100	.025	ina	C	3750	f
	Alfred	6025	8000	12,000	0	full rng	.01-100	1	50	C	8190	
	E-H	574-1	7000	12,000	0	full rng	note 1	.03	50	R	3760	
	Weincshel	X775A	8200	12,400	0	full rng	note 21	.02	50	C,R	2900	
	E-H	574-2	8200	12,400	0	full rng	note 1	.024	50	R	3580	
	MSI	N900X	8200	12,400	0	full rng	ina	.025	50	R	1995	
	Alfred	635A	8000	12,400	0	full rng	.01-100	.02	ina	C,R	3490	a
SW-28	Alfred	655A/650	8000	12,400	0	full rng	.01-100	.02(5)	50	C,R	3375	c,f
	Alfred	655AK/650	8000	12,400	0	full rng	.01-100	.02(4)	50	C,R	3750	c,f
	Alfred	645K	8000	12,400	0	full rng	.01-100	.05(4)	50	C,R	3300	c
	Alfred	655K/650	8000	12,400	0	full rng	.01-100	.05(6)	50	C,R	3500	c,f
	Alfred	645	8000	12,400	0	full rng	.01-100	.06(2)	50	C,R	2900	c
	Alfred	655/650	8000	12,400	0	full rng	.01-100	.06(6)	50	C,R	3100	c,f
	H-P	8694A/8690A	8000	12,400	0	full rng	.01-100	.05	50	C,R	3125	f
	H-P	8694B/8690A	8000	12,400	0	full rng	.01-100	.03	50	C,R	3475	f
	LFE	832-X-1	8000	12,400	1 MHz	full rng	.01-100	.05-0.15	ina	C,R	request	
	Micro-Power	H812L/220	8000	12,400	0	full rng	.01-100	.05	ina	C	3600	f
SW-29	Servo	X880	8000	12,400	0	full rng	.01-100 Hz	.02	ina	C,R	3050	a
	Alfred	654A-S1/650	7000	12,400	0	full rng	.01-100	.01(5)	50	C,R	3600	c,f
	Alfred	654AK-S1/650	7000	12,400	0	full rng	.01-100	.01(5)	50	C,R	4000	c,f
	Alfred	644K-S1	7000	12,400	0	full rng	.01-100	.015(4)	ina	C,R	3500	a,c
	Alfred	654K-S1/650	7000	12,400	0	full rng	.01-100	.015(6)	50	C,R	3700	c,f
	Alfred	644-S1	7000	12,400	0	full rng	.01-100	.02(2)	ina	C,R	3100	a,c
	Alfred	654-S1/650	7000	12,400	0	full rng	.01-100	.02(6)	50	C,R	3300	c,f
	H-P	H01-8694A/8690A	7000	12,400	0	full rng	.01-100	.025	50	C,R	request	f
	H-P	H01-8694B/8690A	7000	12,400	0	full rng	.01-100	.015	50	C,R	3750	f
	MSI	N900HX	7000	12,400	0	full rng	ina	.015	50	R	1995	
SW-30	Micro-Power	H712L/220	7000	12,400	0	full rng	.01-100	.025	ina	C	3950	f
	Servo	H880	7000	12,400	0	full rng	.01-100 Hz	.01	ina	C,R	3375	a
	Alfred	646	10,000	15,500	0	full rng	.01-100	.035(6)	50	C,R	3450	c
	Alfred	656/650	10,000	15,500	0	full rng	.01-100	.035(6)	50	C,R	3450	c,f
	Alfred	637A	12,400	18,000	0	full rng	.01-100	.01	ina	C,R	3790	a
	Alfred	647K	12,400	18,000	0	full rng	.01-100	.025	ina	C,R	3500	a,c
	Alfred	657K/650	12,400	18,000	0	full rng	.01-100	.025(5)	ina	C,R	3725	c,f
	Alfred	647	12,400	18,000	0	full rng	.01-100	.04(6)	50	C,R	3000	c
	Alfred	657/650	12,400	18,000	0	full rng	.01-100	.04(6)	50	C,R	3200	c,f
	E-H	575	12,400	18,000	0	full rng	note 1	.048	50	R	3730	

Notes, abbreviations and manufacturers' index at end of this section.

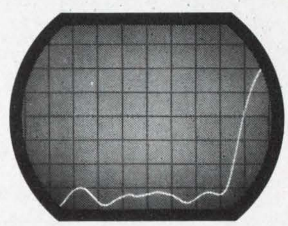


Frequency–From 19 Points of View

The benefits of swept frequency measurement in terms of quicker testing and more precise answers easily justifies the employment of a Sweep Generator in both lab and production applications.



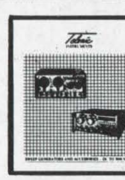
Now, Telonic's SM-2000 Sweep Generator (left) offers these benefits in a configuration that gives the instrument maximum versatility at a low equipment investment. The SM-2000 accepts the 19 different oscillators, shown above, ranging from the LA-1M that covers 20 Hz to 20 KHz to the E-3 that goes to 3120 MHz. The entire spectrum from DC to 3 Gc can be viewed with as much detail as needed. In some cases a whole octave may be displayed on the scope at one time.



The SM-2000 Sweep Generator provides the method, the machinery, and the flexibility for a myriad of frequency measurement applications. Your local Telonic representative would be glad to show you how.

Telonic® INSTRUMENTS
Division of Telonic Industries Inc.
60 North First Avenue, Beech Grove, Indiana 46107
Tel.: (317) 787-3231 TWX: 810-341-3202
SALES REPRESENTATIVES THROUGHOUT THE WORLD. FACTORY OFFICES IN FRANKFURT, GERMANY AND MAIDENHEAD, ENGLAND.

Does your work involve application or manufacture of Power Supplies, Oscillators, RF Circuits, Audio Amplifiers, UHF Tuners, Communication Networks, Crystal Devices, R.F. Filters or the like? Then find out how you can apply swept frequency methods to make your work easier, and more reliable. Telonic Application Techniques cover all these and more. Yours on request.



ON READER-SERVICE CARD CIRCLE 177

Sweep generators 18,000-40,000 MHz

	Manufacturer	Model	FREQUENCY Min. MHz	FREQUENCY Max. MHz	SWEEP WIDTH Min. kHz	SWEEP WIDTH Max. MHz	SWEEP WIDTH Rate Sec	OUTPUT Watts	OUTPUT Imp. Ohms	Type	Price $	Notes
SW-31	H-P	8695A	12,400	18,000	0	full rng	.01-100	.04	50	C,R	3250	
	LFE	832-KU-1	12,400	18,000	1 Mhz	full rng	.01-100	.04-0.2	ina	C,R	request	
	Micro-Power	H1218/220	12,400	18,000	0	full rng	.01-100	.04	ina	C	3650	f
	Servo	U880	12,400	18,000	0	full rng	.01-100 Hz	.003	ina	C,R	4100	a
	Weinschel	Y775A	12,400	18,000	0.2 MHz	full rng	note 22	.01	50	C,R	3300	
	Servo	Y880	10,000	20,000	0	full rng	.01-100 Hz	.003	ina	C,R	4100	a
	H-P	8696A	18,000	26,000	0	full rng	.01-100	.01	50	C,R	4050	
	Alfred	658/650	18,000	26,500	0	full rng	.01-100	.01(6)	50	C,R	3950	c,f
	Alfred	648	18,000	26,500	0	full rng	.01-100	.02(6)	50	C,R	3650	c
	E-H	576	18,000	26,500	0	full rng	note 1	.012	WG	R	4570	
SW-32	Micro-Power	H1826/220	18,000	26,500	0	full rng	.01-100	.02	ina	C	4500	f
	Servo	K880	18,000	26,500	0	full rng	.01-100 Hz	.005	ina	C,R	4500	a
	Weinschel	U775A	27,000	40,000	0.2 MHz	full rng	note 23	.0035	ina	C,R	4300	
	Alfred	659/650	26,500	40,000	0	full rng	.01-100	.005(6)	50	C,R	5650	c,f
	Alfred	649	26,500	40,000	0	full rng	.01-100	.005(6)	50	C,R	5300	c
	E-H	577	26,500	40,000	0	full rng	note 1	.006	WG	R	6870	
	Servo	V880	26,500	40,000	0	full rng	.01-100 Hz	.005	ina	C,R	6350	a
	Micro-Power	H2640/220	26,500	40,000	0	full rng	.01-100	.005	ina	C	6400	f
	H-P	8697A	26,000	40,000	0	full rng	.01-100	.005	50	C,R	5850	

Notes, abbreviations and manufacturers' index at end of this section.

NOTES

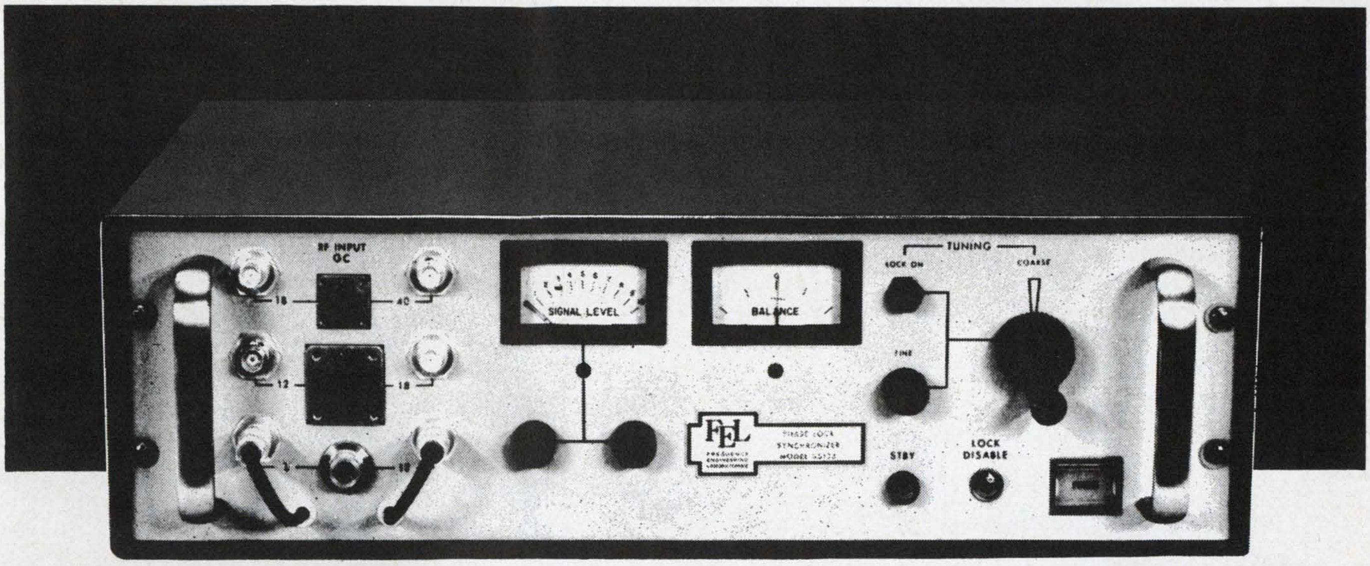
Sweep Generators

a. Zero or blanking output available for scope return trace.
b. Has phasing control of scope output.
c. Input: 115/230 V, 50-400 Hz.
d. Has switched fixed markers
e. Locks to line frequency but may be adjusted to detect hum.
f. Prices shown are for tuning unit and basic oscillator. The basic oscillator can be used with any of this series of tuning heads.

1. Sweep rate .001-1000 seconds.
2. Output unleveled.
3. RF channels adjustable from 5-20 MHz, IF channels adjustable from 10-40% of center frequency.
4. Output leveled or unleveled.
5. Pin diode leveled.
6. Grid leveled.
7. Fixed, 1.67, 5 and 10 kHz.
8. Adjustable 7° to 320°.
9. Adjustable 2.3° to 600° per minute.
10. +3 to -127 dBm.
11. Can measure microwave power from an external source. The rear tuning shaft extension provides programable motor drive.
12. Prices shown are for tuning unit. This tuning unit can be used with model 1500 at $650 extra or the model 860 at $495 extra.
13. 500 kHz for sound IF, 13 MHz for picture.
14. Center frequencies and sweep widths covered by each band;
    Band A - 100 kHz - 12 MHz, width 100 kHz - 12 MHz.
    Band B - 12-20 MHz, width 60% of center frequency.
    Band C - 20-32 MHz, width 60% of center frequency.
    Band D - 32-52 MHz, width 15 MHz.
    Band E - 52-90 MHz, width 20 MHz.
    Band F - 90-150 MHz, width 20 MHz.
15. Center frequencies and sweep widths covered by each band;
    Band A - 100 kHz - 12 MHz, width 100 kHz - 12 MHz.
    Band B - 20-30 MHz, width 60% of center frequency.
    Band C - 35-55 MHz, width 60% of center frequency.
    Band D - 55-215 MHz, width 20-50 MHz at high end of band.
16. Wide band 6 times marker spread, narrow band 3 times marker spread.
17. Prices shown are for tuning unit. This tuning unit can be used with model 1500 at $525 extra or model 121 at $895 extra.
18. Model H07-207A sweep motor drive provides full band sweep speeds of 430 (±10%) or 43 (±10%) seconds.
19. Sweep rate 0.1-100 GHz.
20. Sweep rate 0.2-200 GHz.
21. Sweep rate 300 MHz - 300 GHz.
22. Sweep rate 0.4-400 GHz.
23. Sweep rate 0.1-1000 GHz.

ABBREVIATIONS

C - Cabinet
R - Rack mount
ina - information not available
rng - range



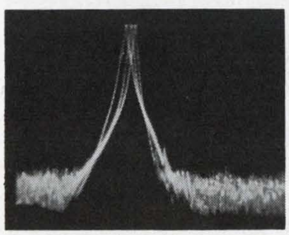
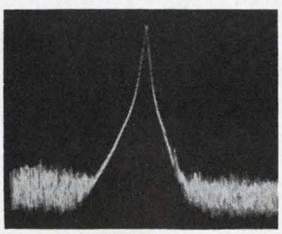
New Continuously Tunable 1 to 40 GHz Synchronizer—Model 136A

FEL's new 136A Synchronizer converts any voltage tunable signal source from 1 to 40 GHz to an ultra stable signal source with stability of 1 part in 10^7 per day and 1 part in 10^8 per second. It extends the capability of your existing signal generator!

Simplified tuning makes the all solid state Model 136A easy to operate. It's continuously tunable over entire range with crystal controlled stability . . . controls any voltage tunable tube or solid state oscillator . . . and has a lock-on indicator lamp. Balance meter and signal level meter are included. New proportional controlled oven provides exceptional short and long term stability.

SPECIFICATIONS

Frequency Range	1.0-40.0 GHz
Tunability	continuous over full range
Frequency Stability	1 part in 10^8 per second 1 part in 10^7 per day
Sample Power Input	— 20 dbm to 0 dbm (greater sensitivity at lower freq.)
Helix/Reflector Voltages	to 5,000V dc
Phase Detector Sensitivity	20 V dc per radian
Power Requirements (115/230 V, 50-400 cps available)	115V, 50/60 cps, approximately 20W
Connector	1-12 GHz Type N 12-18 GHz WR-62 18-40 GHz WR-42
Dimensions	5¼" high; 19" wide; 18" deep
Weight	20 pounds
PRICE	$3,895

Typical spectrum generated by an rf source with and without stabilization, using the FEL-136A. Note simultaneous frequency stabilization and incidental fm reduction in right hand photograph.

OTHER FEL SERIES 130 SYNCHRONIZERS:

Model	Frequency Range (GHz)	Price
133A	1.0-12.4	$2250
134A	12.4-18.0	$2350
135A	18.0-40.0	$3450
137A	1.0-18.0	$2750

Data subject to change without notice; Prices f.o.b. factory.

Expansion has created opportunities for qualified Microwave, Circuit Design and Instrumentation Engineers in Key Positions on our Technical Staff. Send complete resume in confidence to: Supervisor, Professional Employment.

For complete information on the new 136A or any 130 Series Synchronizer, write or call your local FEL field engineering office today or: **FREQUENCY ENGINEERING LABORATORIES, P. O. Box 527, Farmingdale, New Jersey 07727, (201) 938-9221. TWX: 201 - 938-2456.**

73 A

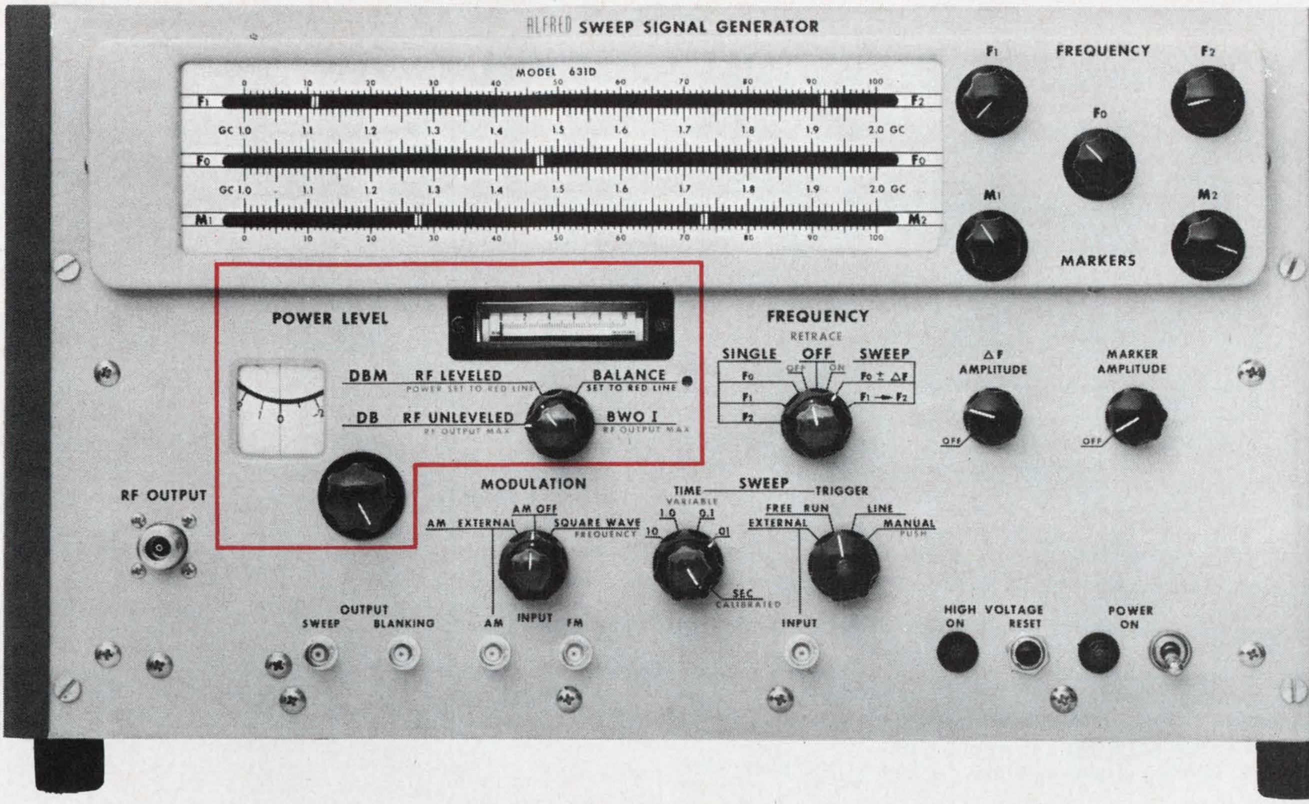
FEL
FREQUENCY
ENGINEERING
LABORATORIES

A DIVISION OF HARVARD INDUSTRIES, INC.

ON READER-SERVICE CARD CIRCLE 178

Index of Manufacturers and Model Numbers

(keyed to table locator symbols)



No, it's not a microwave sweep oscillator. It's the only microwave sweep signal generator!

Here, in one compact package, is the microwave industry's only electronic Sweep Signal Generator. Alfred's new 630D Series now provides precise frequency tuning plus known absolute power output over a 60 db range, calibrated in dbm, all during swept or CW operation. Note these special features:

Flat Output—Feedback leveler holds power variation to less than ±0.5 db at rated output over each range. Variation in any 100 Mc range is less than ±0.1 db. Absolute accuracy ±3/4 db at rated power output.

Multiple Frequency Markers allow frequency calibration with 3 markers during broadband sweep and 2 during symmetrical sweep.

Complete Sweep Flexibility—$F_1 \rightarrow F_2$ sweep for broadband evaluation. $F_0 \pm \Delta F$ symmetrical sweep for expanded display.

Separate F_0 Control independent of $F_1 \rightarrow F_2$ allows switching from broadband sweep to symmetrical sweep without "disadjusting controls."

Transistorized—10½" panel height—lightweight—low power consumption—only five vacuum tubes used.

Stabilized Power Output—Dual bolometers assure constant power output over wide temperature range.

Available in Five Bands—1 to 2, 1.4 to 2.5, 2 to 4, 3.5 to 6.75 and 4 to 8 Gc. Frequency is continuously adjustable over entire range with direct calibrated dial (1% accuracy).

Coverage to 18 Gc—Series 630A provide calibrated level output without the attenuator through 18 Gc in 9 bands.

KEY SPECIFICATIONS

Frequency Range: Model 631D, 1 to 2 Gc; Model 631D-S1, 1.4 to 2.5 Gc; Model 632D, 2 to 4 Gc; Model 633D-S1, 3.5 to 6.75 Gc; Model 633D, 4 to 8 Gc. RF Power: +10 to −50 dbm (+8 to −45 dbm for 633D-S1 and 633D). Continuously variable over full range. Greater power output available unleveled. Residual FM: 50 kc peak (80 kc peak for 633D-S1 and 633D). Drift: ±0.01%. Sweep Width: Continuously adjustable from 2% to 100% of the frequency range. Symmetrical Sweep: 0 to ±5% of range about any frequency. Sweep Time: 100 to 0.01 seconds. Amplitude Modulation: CW, square wave or external.

For complete information, write us at 3176 Porter Drive, Palo Alto, California. Phone: (415) 326-6496.

"Project responsibility opportunities exist for qualified engineers on our technical staff. An equal opportunity employer."

ALFRED ELECTRONICS

8691A/8690A	(SW-16)
8691B/8690A	(SW-16)
8692A/8690A	(SW-19)
8692B/8690A	(SW-19)
H01-8692B/8690A	(SW-21)
8693A/8690A	(SW-24)
8693B/8690A	(SW-24)
H01-8693B/8690A	(SW-25)
8694A/8690A	(SW-28)
H01-8694A/8690A	(SW-29)
H02-8694A/8690A	(SW-27)
8694B/8690A	(SW-28)
H01-8694B/8690A	(SW-29)
H02-8694B/8690A	(SW-27)
8695A	(SW-31)
8696A	(SW-31)
8697A	(SW-32)

Hickok Electrical Instrument Co

288AX	(SW-7)
615	(SW-9)

ITT Industrial Products Div

74217-A	(SW-1)

Jerrold Electronics Corp

601-5B	(SW-9)
602-5B	(SW-6)
890	(SW-14)
900-A	(SW-14)
900-C	(SW-14)
1015	(SW-3)
H-71/707C	(SW-6)
H-72/707C	(SW-7)
H-73/707C	(SW-4)
H-75/707C	(SW-8)
SS-300	(SW-10)

Kay Electric Co

100	(SW-14)
110	(SW-13)
111	(SW-12)
121	(SW-15)
141	(SW-2)
150B	(SW-4)
154A	(SW-6)
159B	(SW-10)
361C	(SW-8)
370A	(SW-4)
380A	(SW-5)
385A	(SW-10)
386	(SW-10)
386AN	(SW-10)
386AR	(SW-5)
865A	(SW-7)
866A	(SW-7)
932A	(SW-8)
932B	(SW-7)
935B	(SW-9)
1483A	(SW-13)
P121/121	(SW-14)
P122/121	(SW-15)
P123	(SW-14)
P124/121	(SW-15)
P130	(SW-3)
P141A	(SW-2)
P142	(SW-2)
P152	(SW-4)
P154	(SW-7)
P855	(SW-4)
P860	(SW-8)
P867	(SW-11)

Kruse-Storke Electronics

5009/5000	(SW-11)
5010/5000	(SW-13)
5011/5000	(SW-16)
5012/5000	(SW-17)

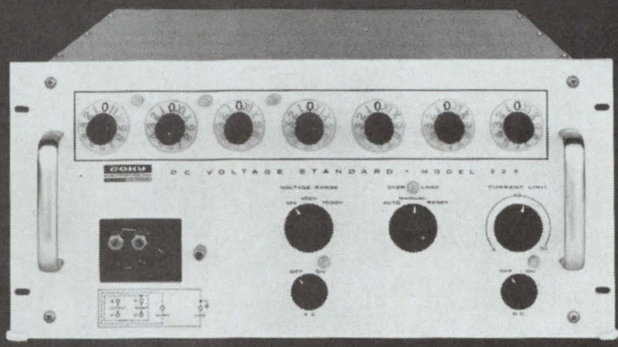
LTV Ling Electronics

CO-10-A	(SW-1)
CO-10-B	(SW-1)

Laboratory For Electronics, Inc (LFE)	
832-C-1	(SW-24)
832-KU-1	(SW-31)
832-L-1	(SW-16)
832-S-1	(SW-19)
832-X-1	(SW-28)
Marconi Instruments	
TF-1099	(SW-4)
Micro-Power, Inc	
H24MD/220	(SW-10)
H25MD/220	(SW-11)
H37MD/220	(SW-11)
H41MD/220	(SW-14)
H51MD/220	(SW-13)
H102L/220	(SW-16)
H142L/220	(SW-18)
H204L/220	(SW-20)
H204LA/220	(SW-21)
H356L/220	(SW-22)
H408L/220	(SW-24)
H408LA/220	(SW-25)
H711L/220	(SW-27)
H712L/220	(SW-30)
H812L/220	(SW-28)
H1218/220	(SW-31)
H1826/220	(SW-32)
H2640/220	(SW-32)
MSI Electronics, Inc	
N900C	(SW-24)
N900H	(SW-27)
N900HX	(SW-29)
N900L	(SW-16)
N900S	(SW-19)
N900X	(SW-27)
Narda Microwave Corp	
64S1	(SW-20)
64S2	(SW-20)
Polarad Electronic Instruments	
1307	(SW-21)
1307-1	(SW-22)
1307-1P	(SW-22)
1307-P	(SW-21)
1308	(SW-23)
1308-1	(SW-25)
1308-1P	(SW-25)
1308-P	(SW-23)
Precision Apparatus Co, Inc (Prec Apparatus)	
E410C	(SW-8)
Probescope Co	
5	(SW-1)
100	(SW-2)
500	(SW-2)
RCA, Electronic Components & Devices	
WR-69A	(SW-5)
Rohde & Schwarz Sales Co, Inc (R & S)	
SMC	(SW-17)
SMC	(SW-18)
SMC	(SW-21)
SMC	(SW-22)
SMC	(SW-26)
SWF	(SW-9)
SWH	(SW-3)
SWLU	(SW-14)
SWOB I	(SW-11)
SWOB II	(SW-15)
SWOF	(SW-4)
Servo Corp of America	
C880	(SW-24)
H880	(SW-30)
J880	(SW-26)
K880	(SW-32)
L880	(SW-17)
P880	(SW-13)

Q880	(SW-11)
R880	(SW-21)
S880	(SW-20)
T880	(SW-21)
U880	(SW-31)
V880	(SW-32)
W880	(SW-25)
X880	(SW-29)
Y880	(SW-31)
Spectral Dynamics Corp of San Diego	
SD-104-1	(SW-1)
SD-104-2	(SW-2)
SD-104-5	(SW-1)
Tel-Instrument Electronics Corp (Tel-Inst)	
1105	(SW-3)
1211	(SW-12)
1212	(SW-8)
1500B	(SW-5)
1902A	(SW-3)
Telonic Industries, Inc	
E-1/SM-2000	(SW-15)
E-2/SM-2000	(SW-17)
E-3/SM-2000	(SW-18)
HD-1A	(SW-12)
HD-3	(SW-7)
HD-4	(SW-3)
HD-7	(SW-5)
L-1/SM-2000	(SW-2)
L-2/SM-2000	(SW-3)
L-3/SM-2000	(SW-3)
L-4/SM-2000	(SW-4)
L-5/SM-2000	(SW-5)
L-6/SM-2000	(SW-7)
L-7/SM-2000	(SW-7)
LA-1M/SM-2000	(SW-1)
LD-5	(SW-5)
LH-2/SM-2000	(SW-6)
PD-2	(SW-6)
PD-3	(SW-10)
PD-7	(SW-10)
PD-8	(SW-13)
S-4/SM-2000	(SW-11)
S-5/SM-2000	(SW-12)
S-6/SM-2000	(SW-14)
SD-3	(SW-12)
SH-1/SM-2000	(SW-11)
SSX-2	(SW-5)
SV-13	(SW-9)
SV-14	(SW-3)
SV-14	(SW-6)
VR-2M/SM-2000	(SW-3)
VR-50M/SM-2000	(SW-13)
1001	(SW-4)
3001/SM-2000	(SW-9)
3005/SM-2000	(SW-13)
Texscan Corp	
CS-76A	(SW-12)
CS-77	(SW-12)
HS-70	(SW-5)
HS-75	(SW-10)
HS-80	(SW-11)
HS-85	(SW-13)
TH-200	(SW-9)
VS-20	(SW-4)
VS-30	(SW-6)
VS-40	(SW-10)
VS-70	(SW-13)
VS-80	(SW-14)
VS-120	(SW-17)
Waveforms, Inc	
610B	(SW-1)
Weinschel Engineering Co, Inc	
C775A	(SW-24)
S775A	(SW-20)
U775A	(SW-32)
X775A	(SW-27)
Y775A	(SW-31)
Wiltron Co	
610	(SW-6)

Manufacturers' addresses and literature offerings in master cross index at front of issue.



Oscillators .016-100 kHz

For information on how to use these tables, turn to page 2

	Oscillators Manufacturer	Model	FREQUENCY Min kHz	Max kHz	Acc %	Stability %	Output Volts	# of ranges	Type	Price $	Notes
OS-1	Nav Comp	1350B	.001	.016	±0.2	0.1	4-12	1	C,R	2195	c
	Ind Test Equip	600	.06	.06	±.005	1	0-10	1	C	459	
	Ind Test Equip	OPS-100	0.4	0.4	±0.1	±0.1	115	1	R	895	
	Ind Test Equip	JF-400	0.4	0.4	±0.1	1	ina	1	C	140	
	Ind Test Equip	1400	0.4	0.4	±.005	1	0-10	1	C	290	
	ITT	74191-A	0.8	0.8	±3	ina	1 mW	1	C	110	a
	Weston	711A-1	.00001	.999	1	ina	1-50	5	R	request	
	ITT	74191-B	1	1	±3	ina	1 mW	1	C	110	a
	Gen Radio	1214-A	0.4	1	2	ina	200 mW	2	C	95	
	Ind Test Equip	1040	0.4	1	0.2	0.2	120[22]	2	C	145	
OS-2	Gen Radio	1307-A	0.4	1	3	ina	2	2	C	130	a
	Ind Test Equip	1040-A	0.4	1	0.2	0.2	120[23]	2	C	220	
	Krohn-Hite	440-B	.001	1	±.05	.005	10	2	C,R	1150	c
	Gen Radio	1305-A	.00001	1	±2	0.2	10	6	R	995	e
	Krohn-Hite	400-C	.009 Hz	1.1	±2	1	10	5	R	465	b
	R & S	SRT	.00001	1.11	±1	±0.3	0.1-1	3	C	1640	b
	H-P	202-A	.008 Hz	1.2	2	1	30	5	C,R	550	e,f
	B & K	1017-A	.002	2	1	0.8 Hz	12.5	2	C,R	1390	
	S-A	2140	0.4	2.5	3	±.05	20	1	R	350	b
	Tech Materiel	TTG-2	0.935	2.805	ina	ina	0.5	2	R	478	c
OS-3	Waveforms	472C	0.3	3	±0.5	.005	8	1	C	225	
	ITT	74191-C	5	5	±3	ina	1 mW	1	C	110	a
	H-P	H48-241A	0.1	10[17]	±0.2	.04	note 16	note c	C	650	
	H-P	H30-241A	0.1	10[18]	±0.2	.04	note 16	note c	C	675	
	Gen Radio	1311-A	.05	10	1	0.1	0-100	11	C,R	225	
	Muirhead	D-880-A/1	.00001	11.2	±0.2	.05	10	5	C	1450	
	Clough-Brengle	179-A	.025	15	2	ina	100 mW	1	C	105	
	ITT	74186-C	.03	16	±1	ina	-80 dBm	2	C	1385	a
	H-P	205AG	.02	20	2	2	5 W	3	C,R	600	e
	B & K	1024A	.02	20	1	7 Hz	12.5	1	C,R	1720	
OS-4	H-P	201C	.02	20	1	2	42.5	3	C,R	250	e
	B & K	1022	.02	20	1	8 Hz	12.5	1	C,R	1150	
	H-P	206A	.02	20	2	2	10	3	C,R	900	e
	ITT	74213-A	.02	20	±2	ina	-50 dBm	3	C	690	a
	ITT	74233-B	.02	20	±1	ina	-40 dBm	3	C	400	a
	Gen Radio	1308-A	.02	20	±3	.03	0-400	3	C,R	1250	
	Grundig	295	.02	20	2	0.5 Hz	8 W	1	C	260	
	Marconi	TF2100	.02	20	±1	.003	8.5[8]	7	C,R	515	
	Marconi	TF2000	.02	20	±1	.003	8.5	7	C,R	925	
	R & S	SIT	.02	20	2	4 Hz	1 W	1	C	1400	
OS-5	Marconi	TF2005	.02[7]	20	±1	.003	8.5	7	C,R	1415	
	Probescope	SG-376/U	.01	20	ina	ina	2[7]	1	C	ina	
	R & S	SRN	.002 Hz	20	2	±.01	10μV-30	4	C	855	
	Krohn-Hite	452	.001	20	±.05	.005	10	2	C,R	1975	c
	Krohn-Hite	450	.0001	20	±.05	.005	10	2	C,R	1485	c
	Radiometer	H032	0	21	2	15 Hz	300μV-100	1	C	449	
	Siemens	W36	.03	30	ina	0.5	1 mV-30	4	C	ina	
	H-P	200AB	.03	40	2	2	24.5	4	C,R	170	b,e
	Gen Radio	1304-B	.03	40	1	ina	5 mV-50	2	R	925	
	Radiometer	H012	0	40	0.5	3 Hz	10μV-50	2	C	1205	
OS-6	Clough-Brengle	405	.02	50	±1.5	ina	100 mW[21]	2	C	340	
	Clough-Brengle	402	.02	50	±1.5	ina	100 mW[8]	2	C	340	
	Krohn-Hite	420-C	.00035	52	±2	1	10	5	C,R	410	b,c
	H-P	203A	.005 Hz	60	±1	1	30	7	C	1200	b,e
	Krohn-Hite	4030	.0001	99.9	1	±.02	10	4	R	note 6	c,f,j
	Optimation	RCD-1	.0001	99.9	±1	.01	0-5[8]	4	C,R	625	b
	Optimation	RCD-4	.0001	99.9	±1	.01	0-5[11]	4	C,R	880	b
	Optimation	AC15	.0001	99.9	1	.01	0-15	4	R	1090	b
	Optimation	RCD-2R	.0001	99.99	±0.1	.01	0-5	4	R	795	b
	B & W	210	.01	100	±2	ina	10	4	C	187	

Notes, abbreviations and manufacturers' index at end of this section.

Oscillators 100-1000 kHz

	Oscillators Manufacturer	Model	FREQUENCY Min kHz	Max kHz	Acc %	Stability %	Output Volts	# of ranges	Type	Price $	Notes
OS-7	Waveforms	401C	.01	100	±3	.005	20	4	C	200	
	Gen Radio	1309-A	.01	100	±2	ina	5	4	C	325	b
	Heath	IG-72	.01	100	±5	ina	.003-10	8	C	42 kit(2)	
	Waveforms	452	.01	100	1	.005	8	4	R	1000	
	Waveforms	471B	.01	100	1	.005	10	4	C	250	
	Waveforms	401B	.01	100	±3	.005	10	4	C	180	
	IERC	ADO-102	.01	100	±1.5	±1	0-50	4	C,R	575	c
	H-P	202C	.001	100	2	2	10	5	C,R	330	e
	Holt	448	.001	100	±1	±0.2	10	5	R	1540	c
	Waveforms	473B	.001	100	1	.005	10	5	C,R	410	
OS-8	Waveforms	403B	.001	100	3	.005	10	5	C,R	350	
	Krohn-Hite	4000	.0001	100	1	±.02	10	3	C,R	850	c
	H-P	3300A/3301A	.00001	100	±1	±0.25	35	7	C	570	f
	Krohn-Hite	440-A	.001 Hz	100	±1	.05	10	5	C,R	625	b,c
	Krohn-Hite	4010	.001 Hz	100	1	±.02	10	5(5)	C,R	925	c
	Krohn-Hite	4020	.001 Hz	100	1	±.02	10	5(4)	C,R	1025	c
	Muirhead	D-890-A/1	.001	111.1	±0.2	±.02	2 W	2	C	1450	c
	Wayne Kerr	S-121	.01	120	1	100 ppm	0-30	37	C	470	
	Probescope	RC-120	.009	120	ina	ina	0-17(7)	1	C	ina	
	B & K	1013	0.2	200	1	80 Hz	12.5	1	C,R	1390	
OS-9	EICO	377	.02	200	±3	ina	10	4	C	55	b
	RCA	WA-44C	.02	200	±5	±2	8	4	C	98	b
	Hathaway	N-1	.002	200	2	ina	1.5	5	C	340	
	Muirhead	K-126-A	.001	222.2	±0.4	±.02	3	4	C	1055	c
	ITT	74254-A	0.3	300	±1	ina	-49 dBm	3	C	700	a
	R & S	SRM	.03	300	2	.01	1	4	C	572	
	Radiometer	RC03	.03	300	1.5	±0.5 dB	0-150	4	C	591	
	Gen Radio	1210C	.02	500	3	1	7	5	C	280	b
	Waveforms	512F	.0005	500	±1	.01	50	6	C	475	
	Krohn-Hite	430-AB	.0046	520	±2	2	10	5	C,R	245	
OS-10	Marconi	TF2001	.03	560	±3	.02	1.1(9)	6	C,R	700	
	H-P	236A	.05	560	±3	0.1	+10 dBm	4	C	525	
	Marconi	TF2101	.03	560	±3	.02	1.1(10)	6	C,R	385	
	H-P	204B	.005	560	±3	0.3	2.5	5	C	315	a
	H-P	208A	.005	560	±3	0.3	2.5	5	C(19)	525	a,e
	Stewart	TO	.0055	600	3	2	5,10	11	C	270	a
	H-P	200CD	.005	600	2	2	10	5	C,R	200	e
	H-P	200S	.005	600	±2	ina	3	5	C,R	230	e
	Waveforms	401H	.005	600	±2	0.1	10	5	C	220	
	Prec Apparatus	E-310	.005	600	±1	ina	10	5	C	200	b
OS-11	ITT	74188-D	4	610	±1	ina	-80 dBm	2	C	1235	a
	ITT	74188-E	4	610	±1	ina	-80 dBm	2	C	1235	e
	ITT	74188-F	4	610(3)	±1	ina	-80 dBm	2	C	1235	a
	Prec Apparatus	E-330	.007	750	±5	ina	10	6	C	130	b
	Gen Radio	1214-M	1000	1000	1	ina	300 mW	1	C	95	
	Hallicrafters	CFS-180A	100	1000	$2/10^{10}$	$2/10^{10}$	0.75	2(12)	C,R	request	
	Hallicrafters	CFS-250A	100	1000	$5/10^{11}$	$5/10^{11}$	1	2(12)	C,R	request	
	H-P	101A	100	1000	.05 ppm	.05 ppm	1	2(12)	C,R	600	
	Century	820B	0.1	1000	.001	1 ppm	0-1	5	R	3400	b,c
	Heath	IG-82	.02	1000	±5	ina	.01-10	5	C	52 kit	b
OS-12	Heath	EUW-27	.02	1000	±5	ina	.01-10	5	C	94 wired	b
	Waveforms	510B	.02	1000	±3	0.5	10	5	C	180	
	Waveforms	510C	.02	1000	±3	0.5	3	5	C	200	
	Clough-Brengle	411	.02	1000	2	ina	10	5	C	120	
	Clough-Brengle	420	.02	1000	2	ina	100 mW	5	C	200	
	R & S	SRB	.01	1000	±1	±.03	1 mV -30	5	C	980	
	H-P	241A	.01	1000	±1	.04	2.5	note c	C	490	e
	H-P	100E	.01	1000	.05 ppm	.05 ppm	5	6(12)	C,R	1000	h
	Century	821B	.01	1000	.001	1 ppm	0-1	5	R	3550	b,c
	Siemens	W38	.01	1000	ina	0.1	20μV-20	8	C	1950	

Notes, abbreviations and manufacturers' index at end of this section.

Oscillators 1-920 MHz

	Oscillators Manufacturer	Model	FREQUENCY Min kHz	Max MHz	Acc %	Stability %	Output Volts	# of ranges	Type	Price $	Notes
OS-13	Waveforms	401F	.001	1	±3	0.1	10	6	C	325	
	Hathaway	N-2A	.001	1	2	ina	0-10	6	C	350	
	Waveforms	471F	.001	1	1	0.1	10	6	C	385	
	Muirhead	K-205-A	.001	1	±1	±.01	3	6	C	670	
	Century	822B	.001	1	.001	1 ppm	0-1	5	R	3700	b,c
	Century	823B	.0001	1	.001	1 ppm	0-1	5	R	3850	b,c
	Century	824B	.00001	1	.001	1 ppm	0-1	5	R	4000	b,c
	H-P	5102A	.00001	1	$3/10^9$	$3/10^9$	1	2	C,R	6500	k
	Century	825B	.001 Hz	1	.001	1 ppm	0-1	5	R	4150	b,c
	Schlumberger	FS-1	0	1.2	$1/10^7$	$3/10^9$	.05	6	C	4250	
OS-14	ITT	74222-A	10	1.5	±0.1	±50 Hz	-80 dBm	1	C	1715	a
	Waveforms	402A	.01	1.5	±2	0.1	8	5	C	450	
	ITT	74308-A	0.3	1.62	.01	±1.5 Hz	-70 dBm	5	C	2400	a,e
	Gen Radio	1310-A	.002	2	±2	0.1	20	6	C	295	
	Schlumberger	FS2	0	2	$1/10^7$	$3/10^9$	.05	6	C	4400	
	Tech Materiel	TTG-2	1999	2.001	ina	ina	1	2	R	478	c
	Tech Materiel	CPS-1	2000	4	$1/10^8$	$1/10^8$	1 W	1	C	request	e
	H-P	106A	100	5(13)	$5/10^{11}$	$5/10^{11}$	1	3(12)	C,R	3450	
	H-P	106B	100	5(14)	$5/10^{11}$	$5/10^{11}$	1	3(12)	C,R	3900	
	H-P	107AR	100	5(13)	$5/10^{10}$	$5/10^{10}$	1	3(12)	C,R	2400	
OS-15	H-P	107BR	100	5(14)	$5/10^{10}$	$5/10^{10}$	1	3(12)	C,R	2750	
	Tech Materiel	PMO-4	2000	8	30 ppm	20 ppm	2 W	1	C	request	
	Wayne Kerr	O-22D	10	10	1	ina	note 1	6	C,R	780	b
	H-P	651B	.01	10	±2	.02	3.16	6	C	590	e
	H-P	652A	.01	10	±2	.02	3.16	6	C(20)	725	e
	Marconi	TF1370A	.01	10	±2	±0.1	1 mV-3	6	C,R	995	b
	R & S	SBF	.01	10	±2	±.01	1 μV-10	8	C	1960	
	H-P	5103A	.0001	10	$3/10^9$	$3/10^9$	1	2	C,R	7100	k
	Waveforms	511A	10	12	3	.005	3	6	C,R	700	b
	Measurements	139	3000	20	±1	ina	0.5	4	C	165	
OS-16	ITT	74195-B	50	20	±400 Hz	±5	-80 dBm	1	C	5225	
	ITT	74306-A	10	20	±1	ina	-50 dBm	8	C	1095	a
	Tech Materiel	TRX-1	540	32	ina	1 ppm	1	10	R	560	
	Schlumberger	FS30	10	32	$1/10^7$	$3/10^9$	1.3	6	C	4650	
	Tech Materiel	CPO-1A	1750	33.75	ina	1 ppm	1 W	ina	C	request	
	Hallicrafters	MHS-400	2000	34	ina	$1/10^8$	0.1-2.5	4	C,R	request	k
	PRD	VHF9922	30	40	ina	ina	10	1	R	request	
	Microdot	404A	10,000	50	±1	±.002	50 W	1	C	2975	h
	Gen Radio	1211-C	500	50	±2	0.4	1.5 W	2	C	415	
	Schlumberger	DO1001	50	50	$2/10^8$	$1/10^9$	1	1	C	5750	
OS-17	Gen Radio	1330-A	5	50	±5	ina	12	8	C	825	
	H-P	5100A/5110A	.00001	50	$3/10^9$	$3/10^9$	1	note 15	C,R	12,500	k
	Tech Materiel	VOX-5	2000	64	ina	$1/10^5$	2	5	R	request	
	Jerrold	CM-11	10,000	100	.003	ina	1	3	C,R	request	
	Tektronix	191	50	100	2	.01	5 mV-5	7	C	400	
	Microdot	406A	50,000	200	±1	±.002	50 W	1	C	2975	h
	Arenburg	PG-650C	12	210	2	2	0-600	21	R	1750	h
	Kay	990	4500	220	±1	ina	1	6	C	375	
	Gen Radio	1215-C	50,000	250	±1	0.2	120 mW	1	C	275	
	Weinschel	MS-1	50,000	250	±1	2 Hz	40 mW	1	R	1950	b
OS-18	Weinschel	MS-12A/MO-3	50,000	250	±1	±0.1	80 mW	1	R	2275	b,d
	PRD	UHF9922	20,000	400	ina	ina	2	1	R	request	
	Prec Apparatus	E-200C	88	440	ina	ina	80	1	C	120	
	Schlumberger	FS500	27,000	470	ina	$5/10^8$	1	ina	C	4925	
	Microdot	408B	200 MHz	500	±1	±.002	50 W	1	C	2850	h
	Sierra	470A-500	200 MHz	500	ina	±0.2	50 W	1	C	2650	
	Gen Radio	1208-C	65,000	500	±2	0.5	240 mW	1	C	325	
	H-P	3200B	10,000	500	±2	±.002	25-200mW	6	C	475	
	Gen Radio	1209-CL	180 MHz	600	±1	0.2	320 mW	1	C	360	
	Weinschel	MS-2	250 MHz	920	±1	2 Hz	100 mW	1	R	2200	b

Notes, abbreviations and manufacturers' index at end of this section.

Oscillators 920-6100 MHz

	Oscillators Manufacturer	Model	FREQUENCY Min MHz	Max MHz	Acc %	Stability %	Output mW	# of ranges	Type	Price $	Notes
OS-19	Weinschel	MS-13/MO-3	250	920	±1	±0.1	0.1	1	R	2400	b,d
	App Microwave	C202	150	950	±0.5	±.002	0.1	3	C,R	request	d
	Gen Radio	1209-C	250	960	±1	0.2	150	1	C	360	
	Microdot	410B	500	1000	±1	±.002	.05	1	C	2850	h
	Sierra	470A-1000	470	1000	ina	±0.2	.05	1	C	2650	
	Gen Radio	1361-A	450	1050	±1	0.2	150	1	C	365	
	Sierra	470A-1800	1000	1800	ina	.01	.04	1	C	request	
	Microdot	411A	900	1800	±1	±.002	.025	1	C	2975	h
	LFE	831-L-1	1000	2000	0.1	$2/10^6$	80	1	C,R	5550	
	S-A	2120/28-1B	1000	2000	±5	±0.1	100	1	C	5450	d
OS-20	PRD	L712	950	2000	±1	ina	10	1	C	1195	b,h
	Weinschel	L772A	950	2000	±1	ina	100	1	C,R	1150	
	S-A	2162	950	2000	±1	25 ppm	.001	1	C,R	2500	
	PRD	L9922	900	2000	ina	ina	0 dBm	1	R	request	
	Weinschel	MS-3	900	2000	±1	2 Hz	50	1	R	2750	b
	Gen Radio	1218-B	900	2000	±1	0.1	200	1	C	595	
	S-A	2130	50	2000	±2	±0.5	150	3	C	3850	
	Weinschel	MS-8/MO-3	900	2200	±1	±.01	20	1	R	3200	b,d
	Polarad	1205	950	2400	±0.5	.0008	50	1	C	1425	i
	LFE	814A-L-9	2000	2500	0.1	$5/10^8$	100	1	C	4250	
OS-21	FEL	CG121L-10C	2000	2500	±.01	1 ppm	100	1	C	4675	d
	Sierra	470A-2500	1800	2500	ina	.01	.025	1	C	request	
	Gen Radio	1220-A1	2700	2960	ina	ina	100	1	C	385	c
	Microdot	413A	1800	3000	±1	±.002	.005	1	C	3500	h
	Narda	451A	750	3000	±1	ina	300	1	C	1325	
	Airborne	125	0.2	3000	±1	.004	.05	3	C,R	3450	
	LFE	814A-S-1	2500	3050	0.1	$5/10^8$	75	1	C	3950	
	FEL	CG121S-20C	2500	3200	±.01	1 ppm	100	1	C	4237	d
	Gen Radio	1220-A2	2950	3275	ina	ina	90	1	C	408	c
	LFE	814A-S-2	2950	3600	0.1	$5/10^8$	80	1	C,R	3950	
OS-22	FEL	CG121S-21C	2900	3600	±.01	1 ppm	100	1	C	4237	d
	Gen Radio	1220-A3	3400	3960	ina	ina	90	1	C	415	c
	FEL	CG121S-22C	3300	4000	±.01	1 ppm	100	1	C	5350	d
	S-A	2120/28-2	2000	4000	±5	±0.1	70	1	C	4975	d
	S-A	2163	2000	4000	±1	25 ppm	.001	1	C,R	2500	
	LFE	831-S-1	2000	4000	0.1	$2/10^6$	40	1	C,R	4950	
	Weinschel	S772A	1900	4000	±1	ina	100	1	C,R	1150	
	PRD	S712	1900	4000	±1	ina	10	1	C	1010	b,h
	S-A	2150	2000	4100	1	25 ppm	500	1	C	2200	b
	Gen Radio	1360-B	1700	4100	±1	5 ppm	50	2	C,R	1350	g
OS-23	Weinschel	MS-9/MO-3	2100	4200	±1	±.01	50	1	R	3150	b,d
	Strand	800	2100	4200	0.1	.001	10	1	C,R	5950	
	Polarad	1206	1950	4200	±0.5	.0008	50	1	C	1425	i
	RFD	712	1700	4200	±0.25	ina	ina	1	R	ina	
	LFE	814A-S-31	3700	4300	0.1	$5/10^8$	.001	1	C	request	
	FEL	CG121C-30C	3900	4400	±.01	1 ppm	100	1	C	5475	d
	Gen Radio	1220-A4	3840	4460	ina	ina	75	1	C	422	c
	FEL	G100C-1R	4625	4860	.0005	±.0001	10	1	C	ina	
	Gen Radio	1220-A5	4240	4910	ina	ina	100	1	C	415	c
	FEL	CG121C-31C	4400	5000	±.01	1 ppm	100	1	C	5375	d
OS-24	LFE	814A-C-10	5400	5900	0.1	$5/10^8$	200	1	C,R	3950	
	Strand	700-1	5300	5900	0.1	.001	50	1	C,R	3600	
	FEL	CG121C-32C	5100	5900	±.01	1 ppm	75	1	C	4050	d
	Gen Radio	1220-A6	5100	5900	ina	ina	80	1	C	412	c
	LFE	814A-C-1	5100	5900	ina	$5/10^8$	60	1	C,R	3750	
	FEL	G110C-1C	5000	6000	±.0001	ina	1	1	C	14,000	c
	App Microwave	PG1K	100	6000	0.2	.001	2 kW	1	C,R	request	d
	App Microwave	PH5K	100	6000	0.2	.001	5 kW	1	C,R	request	d
	App Microwave	PH20K	100	6000	0.2	.001	20 kW	1	C,R	request	d
	App Microwave	C201	150	6100	0.5	.002	1-60 W	1	C,R	request	d

Notes, abbreviations and manufacturers' index at end of this section.

Oscillators 6.1-33.52 GHz

	Oscillators Manufacturer	Model	FREQUENCY Min GHz	Max GHz	Acc %	Stability %	Output mW	# of ranges	Type	Price $	Notes
OS-25	App Microwave	PG5K	0.15	6.1	ina	ina	5 kW	1	C,R	request	d
	Strand	700	5.9	6.3	0.1	.001	.001	1	C,R	4500	
	FEL	CG121C-33C	5.925	6.425	±.01	1 ppm	100	1	C	5290	d
	Gen Radio	1220-A7	5.925	6.45	ina	ina	100	1	C	388	c
	Strand	700-2	6	6.5	0.1	.001	.001	1	C,R	4500	
	LFE	814A-C-31	5.9	6.5	0.1	$5/10^8$	.001	1	C,R	request	
	LFE	814A-C-12	5.4	6.5	0.1	$5/10^8$	200	1	C,R	4650	
	Strand	700-3	6.5	7	0.1	.001	.001	1	C,R	4500	
	Weinschel	MS-10/MO-3	4	7.3	±1	±.01	50	1	R	3450	b,d
	Gen Radio	1220-A8	6.2	7.425	ina	ina	90	1	C	388	c
OS-26	S-A	2120/28-4	4	8	±5	±0.1	20	1	C	5375	d
	LFE	831-C-1	4	8	0.1	$5/10^6$	20	1	C,R	4950	
	S-A	2164-2-8	2	8	±1	20 ppm	.001	2	C	11,700	
	S-A	2164-1-8	0.95	8	±1	20 ppm	.001	3	C	15,900	
	Polarad	1207-M1	3.8	8.1	±0.5	ina	80	1	C	1950	i
	Weinschel	C772A	3.95	8.2	±1	ina	100	1	C,R	1295	
	Polarad	1207	3.8	8.2	±0.5	ina	25	1	C	1450	i
	Strand	750	7.5	8.5	0.1	.001	.001	1	C,R	4500	
	LFE	814A-X-5	7.5	8.5	0.1	$5/10^8$	200	1	C,R	4250	
	FEL	CG121X-40C	7.5	8.5	±.01	1 ppm	100	1	C	5425	d
OS-27	Strand	300-A	8.5	9.6	$5/10^4$	.001	20	1	C	2000	
	LFE	814A-X-21	8.5	10	0.1	$5/10^8$	500	1	C,R	3750	
	FEL	CG121X-41C	8.5	10	±.01	1 ppm	100	1	C	3760	d
	Strand	500	8.5	10	0.1	.0001	500	1	C,R	3600	
	Weinschel	MS-30/MO-4	7.5	10	±0.1	ina	50	1	R	4320	b,d
	LFE	814A-X-12	9.8	10.3	0.1	$5/10^8$	200	1	C,R	4300	
	LFE	814A-X-2	9	10.5	0.1	$5/10^8$	55	1	C,R	3750	
	FEL	CG121X-42C	9	10.5	±.01	1 ppm	75	1	C	3730	d
	Weinschel	MS-11/MO-3	7.2	10.5	±.01	ina	50	1	R	3475	b,d
	Strand	230	9.6	10.6	0.1	.001	75	1	C,R	request	
OS-28	Weinschel	X772A	7	11	±1	ina	100	1	C,R	1295	
	Polarad	1208	6.95	11	±0.5	ina	25	1	C	1425	i
	LFE	814A-X-3	9.8	11.2	0.1	$5/10^8$	500	1	C,R	4650	
	PRD	X712	8.2	12	±1	ina	10	1	C	1300	b,h
	FEL	CG121X-43C	10.6	12.4	±.01	1 ppm	75	1	C	5250	d
	Weinschel	MS-31/MO-4	8.2	12.4	±0.1	ina	50	1	R	3790	b,d
	Strand	400	8.2	12.4	0.1	.001	60	1	C,R	4500	
	LFE	831-X-1	8.2	12.4	.05	$1/10^6$	50	1	C,R	4950	
	S-A	2120/28-8	8	12.4	±5	±0.1	20	1	C	5450	d
	S-A	2164-2-12	2	12.4	±1	20 ppm	.001	3	C	16,200	
OS-29	S-A	2164-1-12	0.95	12.4	±1	20 ppm	.001	4	C	20,400	
	FEL	CG121K-50C	12.8	14.2	±.02	1 ppm	100	1	C	request	d
	LFE	814A-K-21	12.4	14.5	0.1	$5/10^8$	100	1	C,R	3950	
	Strand	210	12.5	15	0.1	.001	125	1	C,R	4000	
	FEL	CG121K-51C	14.2	15.8	±.02	1 ppm	75	1	C	request	d
	FEL	CG121K-52C	15.8	17.5	±.02	1 ppm	100	1	C	request	d
	Strand	200	15.5	17.5	0.1	.001	15	1	C,R	3600	
	Strand	201	15.5	17.5	0.1	.001	50	1	C,R	3600	
	LFE	814A-K-22	15	17.5	0.1	$5/10^8$	200	1	C,R	4950	
	Weinschel	MS32/MO-4	12.4	18	±0.1	ina	25	1	R	4350	b,d
OS-30	LFE	831-K-1	12.4	18	0.1	$2/10^6$	40	1	C,R	5550	
	S-A	2120/28-12.4	12.4	18	±5	±0.1	20	1	C	5395	d
	Polarad	EHF-S1821-5	18	22	±0.1	ina	10	1	C	3545	d,i
	LFE	817-K-24	23	25	0.1	$1/10^7$	100	1	C,R	6500	
	Strand	150	23	25	0.1	.001	40	1	C,R	4500	
	Polarad	EHF-S2225-1	22	25	±0.1	ina	10	1	C	3545	d,i
	S-A	2120/28-18	18	26.5	±5	±0.1	10	1	C	6880	d
	Polarad	EHF-S2427-1	24.7	27.5	±0.1	ina	10	1	C	3545	d,i
	Polarad	EHF-S2730-1	27.27	30	±0.1	ina	10	1	C	3575	d,i
	Polarad	EHF-S2933-1	29.7	33.52	±0.1	ina	10	1	C	3575	d,i

Notes, abbreviations and manufacturers' index at end of this section.

Oscillators 36-75 GHz

	Oscillators Manufacturer	Model	FREQUENCY Min GHz	Max GHz	Acc %	Stability %	Output mW	# of ranges	Type	Price $	Notes
	LFE	817-K-35	34	36	0.1	$5/10^8$	100	1	C,R	7500	
	Polarad	EHF-S3336-1	33.52	36.25	±0.1	ina	10	1	C	3575	d,i
	Strand	100	32	37	0.1	.001	16	1	C,R	5300	
	Polarad	EHF-S3540-1	35.1	39.7	±0.1	ina	5	1	C	3575	d,i
	S-A	2120/28-27	26.5	40	±5	±0.1	5	1	C	7150	d
OS-31											
	FEL	PLG122	2	40	ina	ina	50	1	C	request	d
	Polarad	EHF-S4046-1	39.6	46	±0.1	ina	3	1	C	3575	d,i
	Polarad	EHF-S4640-1	45.9	50	±0.1	ina	3	1	C	3575	d,i
	Strand	50	50	75	0.1	.001	300	1	C,R	request	

Oscillators Late arrivals

	Kruse-Storke	6000-1	0.3	0.5	±.05	$1/10^8$	.0015	1	C,R	3400	
	Kruse-Storke	6000-2	0.3	0.5	±.05	$1/10^8$	.003	1	C,R	3600	
	Kruse-Storke	6000-3	0.5	0.7	±.05	$1/10^8$	.001	1	C,R	3400	
	Kruse-Storke	6000-4	0.5	0.7	±.05	$1/10^8$	.002	1	C,R	3600	
OS-32	Kruse-Storke	6000-5	0.7	1.4	±.05	$1/10^8$	.0005	1	C,R	3800	
	Kruse-Storke	6000-6	0.7	1.4	±.05	$1/10^8$	.001	1	C,R	4000	
	Kruse-Storke	6000-7	1.4	2.1	±.05	$1/10^8$	.0005	1	C,R	4000	
	Kruse-Storke	6000-8	2.1	3.8	±.05	$1/10^8$	.0002	1	C,R	4000	
	Kruse-Storke	6000-9	2.1	3.8	±.05	$1/10^8$	.001	1	C,R	request	

Notes, abbreviations and manufacturers' index at end of this section.

NOTES (Oscillators)

a. Battery operated
b. Also squarewave generator
c. Frequency set by pushbutton or rotary switch
d. Includes basic power supply with interchangeable tuning units
e. Input: 115/230 V, ±10%, 60-60 Hz
f. Also squarewave and function generator
g. Also squarewave and pulse generator
h. Also pulse generator
i. Also squarewave and sawtooth generator
j. Programable
k. Frequency synthesizer

1. +10 dB to -50 dB
2. $65 wired
3. 140Ω or 600Ω balanced or unbalanced
4. 0-10 V in 1 mV steps
5. 0-9 V in 1 V steps
6. $1335-2185 depending on options desired
7. Two independent oscillator sections
8. Output impedance - 600Ω
9. Attenuator 111 dB, 3 decade
10. Uncalibrated potentiometer
11. Output impedance - 600-1250Ω
12. Crystal controlled
13. Requires 22-30 V dc
14. Contains standby power supply
15. Selectable in steps of .01 Hz, also variable through 1 MHz
16. -30 to +10 dBm
17. Input: 48 V dc, ±4 V positive ground
18. Input: 30 V dc, ±3 V positive ground
19. Includes meter calibrated in volts or dBm
20. Includes X20 meter expand
21. Output impedance - 4000Ω
22. Also 12 V and 60 V
23. Also 15 V and 30 V

ABBREVIATIONS

C - Cabinet
R - Rack mount
ina - Information not available

Index of Manufacturers and Model Numbers

(keyed to table locator symbols)

Airborne Instrument Laboratory

125	(OS-21)

Applied Microwave Laboratory (App Microwave)

C201	(OS-24)
C202	(OS-19)
PG1K	(OS-24)
PG5K	(OS-25)
PH5K	(OS-24)
PH20K	(OS-24)

Arenburg Ultrasonic Laboratory, Inc (Arenburg)

PG-650C	(OS-17)

B & K Instruments, Inc

1013	(OS-8)
1017-A	(OS-2)
1022	(OS-4)
1024A	(OS-3)

Barker & Williamson, Inc (B & W)

210	(OS-6)

Century Electronics & Instruments

820B	(OS-11)
821B	(OS-12)
822B	(OS-13)
823B	(OS-13)
824B	(OS-13)
825B	(OS-13)

Clough-Brengle Co

179-A	(OS-3)
402	(OS-6)
405	(OS-6)
411	(OS-12)
420	(OS-12)

Electronic Instrument Co, Inc (EICO)

377	(OS-9)

Frequency Engineering Laboratory (FEL)

CG121C-30C	(OS-23)
CG121C-31C	(OS-23)
CG121C-32C	(OS-24)
CG121C-33C	(OS-25)
CG121K-50C	(OS-29)
CG121K-51C	(OS-29)
CG121K-52C	(OS-29)
CG121L-10C	(OS-21)
CG121S-20C	(OS-21)
CG121S-21C	(OS-22)
CG121S-22C	(OS-22)
CG121X-40C	(OS-26)
CG121X-41C	(OS-27)
CG121X-42C	(OS-27)
CG121X-43C	(OS-28)
G100C-1R	(OS-23)
G110C-1C	(OS-24)
PLG122	(OS-31)

General Radio Co (Gen Radio)

1208-C	(OS-18)
1209-C	(OS-19)
1209-CL	(OS-18)
1210C	(OS-9)
1211-C	(OS-16)
1214-A	(OS-1)
1214-M	(OS-11)
1215-C	(OS-17)
1218-B	(OS-20)
1220-A1	(OS-21)
1220-A2	(OS-21)
1220-A3	(OS-22)
1220-A4	(OS-23)
1220-A5	(OS-23)
1220-A6	(OS-24)
1220-A7	(OS-25)
1220-A8	(OS-25)
1304-B	(OS-5)
1305-A	(OS-2)
1307-A	(OS-2)
1308-A	(OS-4)
1309-A	(OS-7)
1310-A	(OS-14)
1311-A	(OS-3)
1330-A	(OS-17)
1360-B	(OS-22)
1361-A	(OS-19)

Grundig

295	(OS-4)

Hallicrafters Co

CFS-180A	(OS-11)
CFS-250A	(OS-11)
MHS-400	(OS-16)

Hathaway Instruments, Inc

N-1	(OS-9)
N-2A	(OS-13)

Heath Co

EUW-27	(OS-12)
IG-72	(OS-7)
IG-82	(OS-11)

Hewlett-Packard Co (H-P)

100E	(OS-12)
101A	(OS-11)
106A	(OS-14)
106B	(OS-14)
107AR	(OS-14)
107BR	(OS-15)
200AB	(OS-5)
200CD	(OS-10)
200S	(OS-10)
201C	(OS-4)
202-A	(OS-2)
202C	(OS-7)
203A	(OS-6)
204B	(OS-10)
205AG	(OS-3)
206A	(OS-4)
208A	(OS-10)
236A	(OS-10)
241A	(OS-12)
651B	(OS-15)
652A	(OS-15)
3200B	(OS-18)
3300A/3301A	(OS-8)
5100A/5110A	(OS-17)
5102A	(OS-13)
5103A	(OS-15)
H30-241A	(OS-3)
H48-241A	(OS-3)

Holt Instrument Co

448	(OS-7)

Industrial Test Equipment Co
(Ind Test Equip)

600	(OS-1)
1040	(OS-1)
1040-A	(OS-2)
1400	(OS-1)
JF-400	(OS-1)
OPS-100	(OS-1)

International Electronic Research Corp
(IERC)

ADO-102	(OS-7)

ITT - Industrial Products Division

74186-C	(OS-3)
74188-D	(OS-11)
74188-E	(OS-11)
74188-F	(OS-11)
74191-A	(OS-1)
74191-B	(OS-1)
74191-C	(OS-3)
74195-B	(OS-16)
74213-A	(OS-4)
74222-A	(OS-14)
74233-B	(OS-4)
74254-A	(OS-9)
74306-A	(OS-16)
74308-A	(OS-14)

Jerrold Electronics Corp

CM-11	(OS-17)

Kay Electric Co

990	(OS-17)

Krohn-Hite Corp

400-C	(OS-2)
420-C	(OS-6)
430-AB	(OS-9)
440-A	(OS-8)
440-B	(OS-2)
450	(OS-5)
452	(OS-5)
4000	(OS-8)
4010	(OS-8)
4020	(OS-8)
4030	(OS-6)

Kruse-Storke Electronics

6000-1	(OS-32)
6000-2	(OS-32)
6000-3	(OS-32)
6000-4	(OS-32;
6000-5	(OS-32)
6000-6	(OS-32)
6000-7	(OS-32)
6000-8	(OS-32)
6000-9	(OS-32)

Laboratory For Electronics, Inc (LFE)
Electronics Division

814A-C-1	(OS-24)
814A-C-10	(OS-24)
814A-C-12	(OS-25)
814A-C-31	(OS-25)
814A-K-21	(OS-29)
814A-K-22	(OS-29)
814A-L-9	(OS-20)
814A-S-1	(OS-21)
814A-S-2	(OS-21)
814A-S-31	(OS-23)
814A-X-2	(OS-27)
814A-X-3	(OS-28)
814A-X-5	(OS-26)
814A-X-12	(OS-27)
814A-X-21	(OS-27)
817-K-24	(OS-30)
817-K-35	(OS-31)

831-C-1	(OS-26)
831-K-1	(OS-30)
831-L-1	(OS-19)
831-S-1	(OS-22)
831-X-1	(OS-28)

Marconi Instruments

TF1370A	(OS-15)
TF2000	(OS-4)
TF2001	(OS-10)
TF2005	(OS-5)
TF2100	(OS-4)
TF2101	(OS-10)

Measurements

139	(OS-15)

Microdot, Inc

404A	(OS-16)
406A	(OS-17)
408B	(OS-18)
410B	(OS-19)
411A	(OS-19)
413A	(OS-21)

Muirhead Instruments, Inc

D-880-A/1	(OS-3)
D-890-A/1	(OS-8)
K-126-A	(OS-9)
K-205-A	(OS-13)

Narda Microwave Corp

451A	(OS-21)

Navigation Computer Corp (Nav Comp)

1350B	(OS-1)

Optimation, Inc

RCD-1	(OS-6)
RCD-2R	(OS-6)
RCD-4	(OS-6)
AC15	(OS-6)

PRD Electronics, Inc

L712	(OS-20)
S712	(OS-22)
X712	(OS-28)
L9922	(OS-20)
UHF9922	(OS-18)
VHF9922	(OS-16)

Polarad Electronic Instruments

1205	(OS-20)
1206	(OS-23)
1207	(OS-26)
1207-M1	(OS-26)
1208	(OS-28)
EHF-S1821-5	(OS-30)
EHF-S2225-1	(OS-30)
EHF-S2427-1	(OS-30)
EHF-S2730-1	(OS-30)
EHF-S2933-1	(OS-30)
EHF-S3336-1	(OS-31)
EHF-S3540-1	(OS-31)
EHF-S4046-1	(OS-31)
EHF-S4640-1	(OS-31)

Precision Apparatus Co, Inc
(Prec Apparatus)

E-200C	(OS-18)
E-310	(OS-10)
E-330	(OS-11)

Probescope Co

RC-120	(OS-8)
SG-376/U	(OS-5)

RCA, Electronic Components & Devices

WA-44C	(OS-9)

Radiometer Electronics
The London Co

HO12	(OS-5)
HO32	(OS-5)
RC03	(OS-9)

RFD, Inc

712	(OS-23)

Rohde & Schwarz Sales Co, Inc (R & S)

SBF	(OS-15)
SIT	(OS-4)
SRB	(OS-12)
SRM	(OS-9)
SRN	(OS-5)
SRT	(OS-2)

Schlumberger
c/o E.F. Assoc

DO1001	(OS-16)
FS-1	(OS-13)
FS2	(OS-14)
FS30	(OS-16)
FS500	(OS-18)

Scientific - Atlanta, Inc (S-A)

2120/28-1B	(OS-19)
2120/28-2	(OS-22)
2120/28-4	(OS-26)
2120/28-8	(OS-28)
2120/28-12.4	(OS-30)
2120/28-18	(OS-30)
2120/28-27	(OS-31)
2130	(OS-20)
2140	(OS-2)
2150	(OS-22)
2162	(OS-20)
2163	(OS-22)
2164-1-8	(OS-26)
2164-1-12	(OS-29)
2164-2-8	(OS-26)
2164-2-12	(OS-28)

Siemens America, Inc

W36	(OS-5)
W38	(OS-12)

Sierra Electronic Division
Philco Corp

470A-500	(OS-18)
470A-1000	(OS-19)
470A-1800	(OS-19)
470A-2500	(OS-21)

Stewart Bros Div
Instrument Laboratories Corp

TO	(OS-10)

Strand Laboratories, Inc

50	(OS-31)
100	(OS-31)
150	(OS-30)
200	(OS-29)
201	(OS-29)
210	(OS-29)
230	(OS-27)
300-A	(OS-27)
400	(OS-28)
500	(OS-27)
700	(OS-25)
700-1	(OS-24)
700-2	(OS-25)
700-3	(OS-25)
750	(OS-26)
800	(OS-23)

Technical Materiel Corp (Tech Materiel)

CPO-1A	(OS-16)
CPS-1	(OS-14)
PMO-4	(OS-15)
TRX-1	(OS-16)
TTG-2	(OS-2)
TTG-2	(OS-14)
VOX-5	(OS-17)

Tektronix, Inc

191	(OS-17)

Waveforms, Inc

401B	(OS-7)
401C	(OS-7)
401F	(OS-13)
401H	(OS-10)
402A	(OS-14)
403B	(OS-8)
452	(OS-7)
471B	(OS-7)
471F	(OS-13)
472C	(OS-3)
473B	(OS-7)
510B	(OS-12)
510C	(OS-12)
511A	(OS-15)
512F	(OS-9)

Wayne-Kerr Corp

O-22D	(OS-15)
S-121	(OS-8)

Weinschel Engineering Co, Inc

C772A	(OS-26)
L772A	(OS-20)
MS-1	(OS-17)
MS-2	(OS-18)
MS-3	(OS-20)
MS-8/MO-3	(OS-20)
MS-9/MO-3	(OS-23)
MS-10/MO-3	(OS-25)
MS-11/MO-3	(OS-27)
MS-12A/MO-3	(OS-18)
MS-13/MO-3	(OS-19)
MS-30/MO-4	(OS-27)
MS-31/MO-4	(OS-28)
MS-32/MO-4	(OS-29)
S772A	(OS-22)
X772A	(OS-28)

Weston-Boonschaft & Fuchs

711A-1	(OS-1)

Manufacturers' addresses and literature offerings in master cross index at front of issue.

Exclusive!

Single Dial Source and Detector

Simultaneous Tuning of Source and Detector with New Wayne Kerr SR268 (100kHz-100MHz)

With other systems, it is necessary to tune the source to a specific frequency and then the detector must be tuned to the exact same frequency.

The new Wayne Kerr SR268 Source & Detector performs *both* functions *simultaneously* in a *single* operation over the range 100kHz-100MHz at a short-term frequency stability of 0.01%. Frequency accuracy over this range is ±2%.

The simplicity of operation provided by ganged tuning is furthered by the incorporation of common-mode rejection transformers in the input and output networks, reducing any interference or cross-talk from unwanted signals.

Operable simultaneously from an external nine-volt battery and a six-volt battery for pilot light indications, SR268 is ideal for field work, too. SR268 is an ideal companion instrument to Wayne Kerr R. F. Bridge B601, VHF Bridge B801B and precision R. F. Bridge B201.

SPECIFICATIONS	
Frequency Range:	100kHz to 100MHz in 9 bands:
BAND 1	100kHz - 216kHz
BAND 2	216kHz - 465kHz
BAND 3	465kHz - 1000kHz
BAND 4	1.00MHz - 2.16MHz
BAND 5	2.16MHz - 4.65MHz
BAND 6	4.65MHz - 10.0MHz
BAND 7	10.0MHz - 21.6MHz
BAND 8	21.6MHz - 46.5MHz
BAND 9	46.5MHz - 100MHz

Oscillator Output Level:

Maximum output into 75Ω: BANDS 1-7, 2V rms; BAND 8, 1V rms; BAND 9, 0.5V rms

Output Level Control: 39dB in 3dB Steps (75Ω)

Detector Sensitivity:

Maximum Input Required for 10% Meter Reflection: BANDS 1-6, 1μV x (fMHz)½; BANDS 7-8, 10μV; BAND 9, 30μV 46.5MHz - 70MHz, 20μV 70 MHz - 90MHz, 10μV 90MHz - 100MHz
Input Level Control: 4 Steps of 20dB (nominal)

For literature and detailed specifications, write:

Wayne Kerr CORPORATION

18A Frink St., Montclair, N. J. 07042 • Phone (201) 746-2438

INNOVATIONS IN INSTRUMENTATION

ON READER-SERVICE CARD CIRCLE 189

Random noise generators 35 Hz-5400 MHz

For information on how to use these tables, turn to page 2

	Manufacturer	Model	FREQUENCY Min. MHz	Max. MHz	OUTPUT dB	Meter	Noise Source	Type	Price $	Notes
NG-1	Elgenco	301A	0	35 Hz	12 V	yes	note 1	R	1995	
	Elgenco	311A	0	35 Hz[6]	12 V	yes	note 1	R	2895	
	Beckman	1179R	0	35 Hz[17]	12 V	yes	note 1	R	request	
	Beckman	1179A	0	35 Hz	12 V	yes	note 1	R	request	
	Elgenco	321A	0	105 Hz	12 V	yes	note 1	R	2095	
	Elgenco	632A	0	350 Hz[10]	1 V	none	note 8	C,R	2475	
	Marconi	7816	300 Hz	.0034	1 mW	yes	note 8	C,R	1395	
	ITT	74216-A	20 Hz	.004	20 dBm	yes	note 2	C	890	
	Allison	349A	37 Hz	.0192	2 V	none	note 2	R	2050	
	Northeast	TTS-56	20 Hz	.02	±10 dBm	yes	note 3	C	370	
NG-2	B & K	1402	20 Hz	.02	40 V	yes	note 3	C,R	975	
	Elgenco	331A	10 Hz	.02	5 V	yes	note 5	R	1295	
	Beckman	1179R	10 Hz	.02[18]	15 V	yes	note 1	R	request	
	Elgenco	311A	0	.02[7]	12 V	yes	note 1	R	2395	
	Allison	650	5 Hz	.03	1.5 V	yes	note 3	C,R	310	c
	Elgenco	632A	10 Hz	.035[11]	1 V	none	note 8	C,R	2475	
	Allison	348A	22 Hz	.045	2 V	none	note 2	R	1825	
	H H Scott	811-BC	2 Hz	1.5	2.5 V	yes	note 1	C,R	275	
	Gen Radio	1390-B	5 Hz	5	3 V	yes	note 1	C,R	335	
	Elgenco	602A	5 Hz	5	3 V	yes	note 8	C,R	290	
NG-3	Elgenco	603A	5 Hz	5	3 V	yes	note 8	C,R	495	
	Elgenco	624A Series	5 Hz[9]	5[9]	3 V	yes	note 8	C,R	245-525	
	Elgenco	610A	5 Hz	5	1 V	yes	note 8	C,R	1175	
	R & S	SUF	30 Hz	6	1 μV-1 V	yes	note 5	C	1590	
	Marconi	TF2091	.012	12.388	100 mW	yes	note 4	C,R	1495	
	Kay	770	.001	20	0-10	none	note 19	C	250	
	H-P	345B	30	30	5.2	yes	note 3	C,R	100[23]	a,b
	Kay	240	5	220	0-23.8	yes	note 3	C	375	
	Airborne	07006	10	250	0-16	none	note 5	C	125[13]	
	Kay	600	5	400	0-23.8	yes	note 3	C	1595	
NG-4	Kay	403	3	500	0-19	yes	note 3	C	375	
	ARI	NS-C	1	500	0-16	yes	note 3	C	450	
	Gen Micro	504	1	500	15.2	yes	note 3	C	225[16]	a,b
	Gen Micro	503	1	500	0-19	yes	note 3	C	350	
	ARI	NS-LB	100 Hz	500	0-16	yes	note 3	C	850	c
	H-P	343A	10	600	5.2	yes	note 3	C,R	100[23]	a,b
	PRD	904-A	30	1000	0-10,20	yes	note 5	C	490	
	Kay	771	10	1000	0-10	none	note 19	C	250	
	R & S	SKTU	3	1000	0-15	yes	note 3	C	632	
	Kay	310A	1200	1400	15.8[20]	yes	note 1	C	395[22]	a,b
NG-5	Kay	311A	1200	1400	15.8[21]	yes	note 1	C	395[22]	a,b
	Kay	312A	1120	1700	15.8	yes	note 1	C	595[22]	a,b
	Airborne	07002	0	2000	5.83	none	note 14	C	1100	
	Kay	870A	1700	2600	15.8	yes	note 1	C	495[22]	a,b
	Airborne	07010	200	2600	15.6	yes	note 1	C	330[12]	a,b
	Gen Micro	N501C	200	2600	15.6	yes	note 1	C	265[16]	a,b
	Signalite	TN-3	2700	2900	18.5	none	note 1	C	225[25]	a,b
	Kay	780	1	3000	20	yes	note 3	C	790	
	Kay	880A	2200	3300	15.8	yes	note 1	C	495[22]	a,b
	Kay	261A	2600	3900	15.8[21]	yes	note 1	C	175[22]	a,b
NG-6	Kay	260A	2600	3900	15.8[20]	yes	note 1	C	175[22]	a,b
	Airborne	07048	2600	3950	15.3	yes	note 1	C	250[12]	a,b
	D-B	DBL-140-T	2600	3950	16	yes	note 1	C	318[15]	a,b
	Gen Micro	S501C	2600	3950	15.2	yes	note 1	C	300[16]	a,b
	H-P	S347A	2600	3950	15.1	yes	note 1	C,R	390[23]	a,b
	Signalite	XN-727	2600	3950	14.5	none	note 1	C	request	a,b
	Waveline	2200-2	2600	3950	ina	yes	note 1	C	175[24]	a,b
	H-P	349A	400	4000	15.6	yes	note 1	C,R	325[23]	a,b
	Airborne	07012	2000	5000	15.65	yes	note 1	C	395[12]	a,b
	Signalite	TN-17	4600	5400	18.5	none	note 1	C	request	a,b

Notes, abbreviations and manufacturers' index at end of this section.

Random noise generators 5800-120,000 MHz

	Manufacturer	Model	FREQUENCY Min. MHz	FREQUENCY Max. MHz	OUTPUT dB	OUTPUT Meter	Noise Source	Type	Price $	Notes
NG-7	Signalite	XN-895	5100	5800	14.3	none	note 1	C	request	a,b
	Signalite	TN-10	5000	5850	18.5	none	note 1	C	250[25]	a,b
	Kay	271A	3900	5850	15.8[21]	yes	note 1	C	175[22]	a,b
	Gen Micro	G501C	3950	5850	15.3	yes	note 1	C	270[16]	a,b
	H-P	G347A	3950	5850	15.2	yes	note 1	C,R	310[23]	a,b
	Airborne	07049	3950	5850	15.2	yes	note 1	C	250[12]	a,b
	D-B	DBK-140-T	3950	5850	16	yes	note 1	C	290[15]	a,b
	Waveline	2200-3	3950	5850	ina	yes	note 1	C	165[24]	a,b
	Signalite	XN-725	3950	5850	14.5	none	note 1	C	request	a,b
	Kay	270A	3900	5850	15.8[20]	yes	note 1	C	175[22]	a,b
NG-8	Airborne	07004	0	6000	5.83	none	note 14	C	1800	
	Kay	280A	5850	8200	15.8[20]	yes	note 1	C	175[22]	a,b
	D-B	DBJ-140-T	5850	8200	16	yes	note 1	C	285[15]	a,b
	Signalite	XN-726	5850	8200	14.5	none	note 1	C	request	a,b
	Kay	281A	5850	8200	15.8[21]	yes	note 1	C	175[22]	a,b
	Waveline	2200-4	5850	8200	ina	yes	note 1	C	165[24]	a,b
	Airborne	07050	5850	8200	15.6	yes	note 1	C	230[12]	a,b
	Gen Micro	C501C	5300	8200	15.3	yes	note 1	C	265[16]	a,b
	H-P	J347A	5300	8200	15.2	yes	note 1	C,R	300[23]	a,b
	Signalite	TN-2	8500	9600	14.5	none	note 1	C	245[25]	a,b
NG-9	Signalite	TN-1	8500	9600	14.5	none	note 1	C	205[25]	a,b
	Signalite	XN-867	8500	9600	18.5	none	note 1	C	request	a,b
	Airborne	07051	7050	10,000	15.9	yes	note 1	C	220[12]	a,b
	D-B	DBH-140-T	7050	10,000	16	yes	note 1	C	251[15]	a,b
	Gen Micro	J501C	7050	10,000	15.6	yes	note 1	C	250[16]	a,b
	Kay	291A	7050	10,000	15.8[21]	yes	note 1	C	175[22]	a,b
	H-P	H347A	7050	10,000	15.7	yes	note 1	C,R	275[22]	a,b
	Kay	290A	7050	10,000	15.8[20]	yes	note 1	C	175[22]	a,b
	Signalite	TN-13	7050	10,000	14.5	none	note 1	C	475[25]	a,b
	Waveline	2200-5	7050	10,000	ina	yes	note 1	C	165[24]	a,b
NG-10	Airborne	07052	8200	12,400	15.9	yes	note 1	C	190[12]	a,b
	D-B	DBG-140-T	8200	12,400	16	yes	note 1	C	243[15]	a,b
	Waveline	2200-6	8200	12,400	ina	yes	note 1	C	165[24]	a,b
	Kay	300A	8200	12,400	15.8[20]	yes	note 1	C	175[22]	a,b
	H-P	X347A	8200	12,400	15.9	yes	note 1	C,R	225[23]	a,b
	Gen Micro	X501C	8200	12,400	15.6	yes	note 1	C	210[16]	a,b
	Signalite	TN-6	8200	12,400	15.6	none	note 1	C	225[25]	a,b
	Kay	301A	8200	12,400	15.8[21]	yes	note 1	C	175[22]	a,b
	D-B	DBF-140-T	12,400	18,000	16	yes	note 1	C	254[15]	a,b
	Kay	521A	12,400	18,000	15.28	yes	note 1	C	250[22]	a,b
NG-11	Waveline	2200-7	12,400	18,000	ina	yes	note 1	C	225[24]	a,b
	Signalite	TN-7	12,400	18,000	15.8	none	note 1	C	225[25]	a,b
	Gen Micro	U501C	12,400	18,000	15.8	yes	note 1	C	250[16]	a,b
	H-P	P347A	12,400	18,000	16	yes	note 1	C,R	275[23]	a,b
	Airborne	07091	12,000	18,000	16.1	yes	note 1	C	265[12]	a,b
	Gen Micro	K501C	18,000	26,500	18	yes	note 1	C	425[16]	a,b
	Airborne	07053	18,000	26,500	16.1	yes	note 1	C	265[12]	a,b
	Kay	531A	18,000	26,500	15.28	yes	note 1	C	250[22]	a,b
	D-B	DBE-140-T	18,000	26,500	16	yes	note 1	C	281[15]	a,b
	Waveline	2200-8	18,000	26,500	ina	yes	note 1	C	225[24]	a,b
NG-12	Signalite	TN-8	18,000	26,500	15.9	none	note 1	C	225[25]	a,b
	Airborne	07096	26,500	40,000	16	yes	note 1	C	895[12]	a,b
	D-B	DBD-140-T	26,500	40,000	16	yes	note 1	C	297[15]	a,b
	Waveline	2200-10	26,500	40,000	ina	yes	note 1	C	500[24]	a,b
	Gen Micro	A501C	26,000	40,000	18	yes	note 1	C	425[16]	a,b
	Gen Micro	M501C	50,000	75,000	18	yes	note 1	C	750[16]	a,b
	Gen Micro	E501C	60,000	90,000	18	yes	note 1	C	800[16]	a,b
	Gen Micro	F501C	90,000	120,000	18	yes	note 1	C	1000[16]	a,b

Notes, abbreviations and manufacturers' index at end of this section.

Impulse noise generators 35-21,000 MHz

	Manufacturer	Model	FREQUENCY Min. MHz	FREQUENCY Max. MHz	OUTPUT mV	OUTPUT ohms	PULSE Width µs	PULSE Freq. PPS	Meter	Type	Price $	Notes
NG-13	Stoddart	93453-1	500 Hz	35	121 dB	50	10 ns	2-100	none	C	675	
	Empire	IG-102	0.1	1000	70	50	500	2.5-2500	yes	C	975	
	Stoddart	91263-1	.06	1000	101 dB	50	500	50-60	none	C	275	
	Empire	IG-115	.01	1000	100	50	500	50-60	none	C	170	
	Empire	118B	1000	10,000	61 dB	50	50	120-2000	none	C	1790	
	Empire	118A	1000	10,000	11 dB	50	50	120-2000	none	C	1150	
	Polarad	IC-120A	1	10,000	1-3.17	50	30	1000	none	C	1150	
	Polarad	IC-120B	1	10,000	1-3.17	50	30	1000	none	C	1100	
	Polarad	IC-121B	10,000	15,000	-55 dBm	50	30	1000	none	C	1575	
	Polarad	IC-122B	15,000	21,000	-53 dBm	50	30	1000	none	C	1775	

NOTES

a. Meter mounted on power supply.
b. Power supply separate from noise source.
c. Battery operated.

1. Gas tube.
2. Zener diode.
3. Noise diode.
4. Silicon diode.
5. Noise pentode.
6. Dual output, also 0-20 kHz.
7. Dual output, also 0-35 Hz.
8. Solid state.
9. Fixed frequencies available, 5, 10, 20, 50 and 200 Hz; 20, 50, 100, 200, 500 kHz and 5 MHz.
10. Dual output, also 10 Hz - 35 kHz.
11. Dual output, also 0-350 Hz.
12. Type 71 power supply add $165; type 74A noise figure indicator add $765.
13. Type 07112 power supply add $150 or type 74A noise figure indicator, add $765.
14. Two resistive elements one at 77.3°K, the other at 373.1°K, coaxial switch permits selection.
15. Model DB-2140 power supply add $200.
16. Model 551A automatic noise figure meter add $1,095; Model 301A, add $125.
17. Dual output, 10 Hz - 20 kHz.
18. Dual output, 0-35 Hz.
19. Heated resistive element.
20. Flourescent source.
21. Argon source.
22. Model 323-C power supply, add $125.
23. Model 340B and 342A noise figure meters at $715 and $815 respectively.
24. Model 2200M or 2200 power supply at $125 and $300, respectively.
25. Type TA-3 power supply, add $125.

ABBREVIATIONS:

C - Cabinet
R - Rack mount
ina - information not available

Index of Manufacturers and Model Numbers

(keyed to table locator symbols)

INDEX

261A	(NG-5)
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271A	(NG-7)
280A	(NG-8)
281A	(NG-8)
290A	(NG-9)
291A	(NG-9)
300A	(NG-10)
301A	(NG-10)
310A	(NG-4)
311A	(NG-5)
312A	(NG-5)
403	(NG-4)
521A	(NG-10)
531A	(NG-11)
600	(NG-3)
770	(NG-3)
771	(NG-4)
780	(NG-5)
870A	(NG-5)
880A	(NG-5)

Marconi Instruments

TF2091	(NG-3)
7816	(NG-1)

Northeast Electronics Corp

TTS-56	(NG-1)

PRD Electronics, Inc

904-A	(NG-4)

Polarad Electronic Instruments

IC-120A	(NG-13)
IC-120B	(NG-13)
IC-121B	(NG-13)
IC-122B	(NG-13)

Rohde & Schwarz Sales Co, Inc (R & S)

SKTU	(NG-4)
SUF	(NG-3)

H H Scott, Inc

811-BC	(NG-2)

Signalite, Inc

TN-1	(NG-9)
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TN-3	(NG-5)
TN-6	(NG-10)
TN-7	(NG-11)
TN-8	(NG-12)
TN-10	(NG-7)
TN-13	(NG-9)
TN-17	(NG-6)
XN-725	(NG-7)
XN-726	(NG-8)
XN-727	(NG-6)
XN-867	(NG-9)
XN-895	(NG-7)

Stoddart Electro Systems

91263-1	(NG-13)
93453-1	(NG-13)

Waveline, Inc

2200-2	(NG-6)
2200-3	(NG-7)
2200-4	(NG-8)
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2200-10	(NG-12)

Manufacturers' addresses and literature offerings in master cross index at front of issue.

Squarewave generators 100 Hz-10,000 kHz

For information on how to use these tables, turn to page 2

	Manufacturer	Model	FREQUENCY Min Hz	FREQUENCY Max kHz	FREQUENCY Rise μs	FREQUENCY Fall μs	OUTPUT Min Volts	OUTPUT Max Volts	OUTPUT Imp. ohms	OUTPUT Atten dB	Type	Price $	Notes
SQ-1	ENSCO	FG-113	0.1	100 Hz	10	10	20	20	600	note 1	C	295	a
	Weinschel	MO-1C	1 kHz	1	5	5	0	150	100 k	note 2	R	750	
	Krohn-Hite	400-C	.009	1.1	2	2	0	10	10 k	note 2	C,R	465	a
	Alfred	305A	850	1.15	0.2	2	0	60	2.5 k	note 2	C	120	
	EICO	377	60	50	ina	ina	10	10	1 k	cal pot	C	50	a
	Krohn-Hite	420-C	0.35	52	2	2	0	20	10 k	none	C,R	410	a
	Ind Comp	ICI	100 kHz	100	1	1	20	2 k	ina	none	R	2250	
	Gen Radio	1309-A	10	100	0.1	ina	5	5	600	20	C	325	a
	Marconi	TF 1370A	10	100	0.4	ina	.003	3	note 4	note 5	C,R	995	a
	Measurements	71	6	100	0.1	ina	0	75	20/V	note 1	C	195	
SQ-2	Krohn-Hite	440-A	.001	100	0.5	0.5	0	5	1.5 k	none	C,R	625	a
	Krohn-Hite	442-R	.001	100	0.5	0.5	0	5	1.5 k	note 2	R	2375	a
	RCA	WA-44C	20	200	0.15	0.15	10	ina	100 k	ina	C	99	a
	Precise	636	20	200	0.15	ina	0	10	5 k	note 2	C	73	a
	Gen Radio	1210-C	20	500	0.33	ina	0	30	2.5 k	0-50	C	215	a
	Prec. Apparatus	E-310	5	600	0.15	ina	10	10	600	note 1	C	200	a
	Prec. Apparatus	G-34	7	750	0.15	ina	0	20	0-3 k	60	C	100	a
	Tektronix	107	400 kHz	1000	.003	ina	0.1	0.5	52	note 2	C	190	
	Century	820A	100	1000	0.1	ina	0	10	100	ina	R	3400	a
	Tektronix	106	10	1000	.001,.012	.001	.05(3)	12(3)	50,600	note 2	C	590	
SQ-3	Heath	IG-82	20	1000	0.15	ina	0	10	52,220	note 1	C	52	a
	Century	821A	10	1000	0.1	ina	0	10	100	ina	R	3400	a
	Hickok	1715A	1	1000	.02	ina	7	55	75,600	60	C	340	
	Century	822A	1	1000	0.1	ina	0	10	100	ina	R	3400	a
	H-P	211A	1	1000	.02,0.1	ina	3.5	27	75,600	60	C,R	350	
	Century	823A	0.1	1000	0.1	ina	0	10	100	ina	R	3400	a
	Century	824A	.01	1000	0.1	ina	0	10	100	ina	R	3400	a
	Century	825A	.001	1000	0.1	ina	0	10	100	ina	R	3400	a
	Measurements	72	5	5000	.05	ina	0	2,12	75,500	ina	C	248	
	Fairchild	791A	25	10,000	.006	.003	4	40	50,600	note 2	C,R	420	

Notes, abbreviations and manufacturers' index at end of this section.

NOTES

Squarewave Generators

a. Also oscillator.

1. Calibrated potentiometer.
2. Uncalibrated potentiometer.
3. In two steps, .05-0.5V and 0.5-12V.
4. Four switched settings, 75, 100, 130 and 600 ohms.
5. Six 10 dB steps between -50 dB and +10 dB.

NOTES

Function Generators

a. Output - sine, squarewave and triangle.
b. Output - squarewave, pulse and ramp.
c. Output - sine, squarewave and phase.
d. Output - sine, squarewave, triangle, peak and phase.
e. Output - sine, squarewave, triangle and ramp.
f. Output - sine, squarewave, triangle, ramp and slope.
g. Output - sine, squarewave, pulse and cosine.
h. Battery operated or 110-220V, 50-400 Hz.

1. Varies, 300-0.3 ms.
2. Includes independent timing, triggering and gating which allows cross programing of function.
3. This unit is part of modular system 1000 and can be combined with any number of modules to produce a variety of outputs.
4. Includes variable attenuator and 10X multiplier.
5. Does not include dc offset and internal modulation.
6. Includes dc offset and internal modulation.
7. Direct reading decade attenuator.
8. Uncalibrated potentiometer.
9. Voltage controlled generator, seven simultaneous outputs.
10. Voltage controlled generator, nine outputs, differential output. Starting phase and trigger levels adjustable.
11. Sweep, trigger, voltage controlled generator, nine outputs.
12. Trigger, phase lock, voltage controlled generator, nine outputs.
13. Trigger, phase lock, tone burst, voltage controlled generator, nine outputs.

ABBREVIATIONS

C - Cabinet
R - Rack mount
ina - information not available.

Function generators 50 Hz-1000 kHz

For information on how to use these tables, turn to page 2

	Manufacturer	Model	FREQUENCY Min Hz	Max kHz	Rise μs	Fall μs	OUTPUT Min Volts	Max Volts	Imp. ohms	Atten dB	Type	Price $	Notes
FG-1	Houston	SG88	.005	50 Hz	note 1	ina	0.2 mV	22	300-3 k	ina	C	2300	a
	Servo	1995	.005	$1^{(6)}$	ina	ina	0	40	600	note 7	C,R	3275	a
	Servo	1990	.005	$1^{(5)}$	ina	ina	0	40	600	note 4	C,R	2850	a
	Servo	1980	.005	$1^{(5)}$	ina	ina	0	40	600	note 7	C,R	2355	a
	Exact	331	.001	1	0.5	0.5	0	25	500	0-100	C,R	1195	a
	Exact	330	.001	1	0.5	0.5	0	25	500	0-100	C,R	1500	f
	Canoga	903A	.001	1	200	200	0	30	ina	ina	R	3500	a
	H-P	202A	.008	1.2	ina	ina	0	30	40	0-100	C,R	550	a
	Antlab	7207	500	2.5	10	10	0	150	100 k	note 1	C	372	b
	Antlab	7227	500	2.5	10	10	0	150	100 k	note 1	R	475	b
FG-2	S-A	2140	400	2.5	2	ina	0	100	ina	0-20-40	R	350	b
	Exact	255	.001	$10^{(2)}$	5	5	0	30	400	0-100	C,R	785	e
	Exact	251	.001	10	5	5	0.1	30	400	50	C,R	685	f
	Exact	240	.001	10	5	5	0.1	30	200	50	C,R	475	a
	Exact	250	.001	10	5	5	0.1	30	400	50	C,R	595	e
	H-P	203A	.005	60	0.2	0.2	0	30	600	40	C,R	1200	c
	Canoga	910A	.01	99	10	10	0	10	1	cal pot	C,R	4285	d
	Krohn-Hite	4030	0.1	99.9	.02	.02	0	5	ina	note 8	R	request	g
	Krohn-Hite	4004	0.1	100	.02	.02	0	5	50	note 1	C,R	1025	b
	H-P	3300A/ 3301A	.01	100	0.25	0.25	0	35	600	yes	C,R	590	a
FG-3	Exact	G1103	.01	100	note 3	note 3	10	10	50	none	note 3	$165^{(3)}$	
	Argonaut	LRG051	.01	100	2	2	0	100	1 k	yes	C	225	b
	Krohn-Hite	4024	.001	100	.02	.02	0	5	50	note 1	C,R	1100	b
	Exact	G1102	.0005	100	note 3	note 3	10	10	50	none	note 3	$190^{(3)}$	
	Anadex	CU-2	0.5	600	.09	ina	0	20	1 k	note 2	C	650	
	Exact	G1101	.01	1000	note 3	note 3	10	10	50	note 3	note 3	$165^{(3)}$	
	Wavetek	155	.01	1000	.005	.005	.01	10	50	note 7	R	1195	a
	Wavetek	110	.005	1000	.005	.005	.015	32.5	50	note 8	C,R	445	a,h
	Exact	301	.001	1000	.01	.01	0	10	52	ina	C,R	550	a
	Wavetek	114	.0015	$1000^{(11)}$	.005	.005	.015	32.5	50	note 8	C,R	795	e,h
FG-4	Wavetek	112	.0015	$1000^{(10)}$	.005	.005	.015	32.5	50	note 8	C,R	695	e,h
	Wavetek	111	.0015	$1000^{(9)}$	.005	.005	.015	32.5	50	note 8	C,R	545	e,h
	Wavetek	116	.0015	$1000^{(13)}$	.005	.005	.015	32.5	50	note 8	C,R	845	e,h
	Wavetek	115	.0015	$1000^{(12)}$	.005	.005	.015	32.5	50	note 8	C,R	745	e,h

Notes, abbreviations and manufacturers' index at end of this section.

Index of Manufacturers and Model Numbers

(keyed to table locator symbols)

ENSCO Inc

FG-113 (SQ-1)

Exact Electronics Inc.

240 (FG-2)
250 (FG-2)
251 (FG-2)
255 (FG-2)
301 (FG-3)
330 (FG-1)
331 (FG-1)
G1101 (FG-3)
G1102 (FG-3)
G1103 (FG-3)

Fairchild Instrumentation

791A (SQ-3)

General Radio Co (Gen Radio)

1210-C (SQ-2)
1309-A (SQ-1)

Heath Co

IG-82 (SQ-3)

Hewlett-Packard Co (H-P)

202A (FG-1)
203A (FG-2)
211A (SQ-3)
3300A/3301A (FG-2)

Hickok Electrical Instrument Co

1715A (SQ-3)

Houston Omnigraphic Corp

SG-88 (FG-1)

Industrial Components, Inc
(Ind Comp)

IC! (SQ-1)

Krohn-Hite Corp

400-C (SQ-1)
420-C (SQ-1)
440-A (SQ-2)
442-R (SQ-2)
4004 (FG-2)
4024 (FG-3)
4030 (FG-2)

Marconi Instruments

TF1307A (SQ-1)

Measurements

71 (SQ-1)
72 (SQ-3)

Precise Electronics &
Development Corp

635 (SQ-2)

Precision Apparatus Co, Inc
(Prec Apparatus)

E-310 (SQ-2)
G-34 (SQ-2)

RCA, Electronic Components & Devices

WA-44C (SQ-2)

Scientific-Atlanta, Inc. (S-A)

2140 (FG-2)

Servo Corp of America

1980 (FG-1)
1990 (FG-1)
1995 (FG-1)

Tektronix, Inc

106 (SQ-2)
107 (SQ-2)

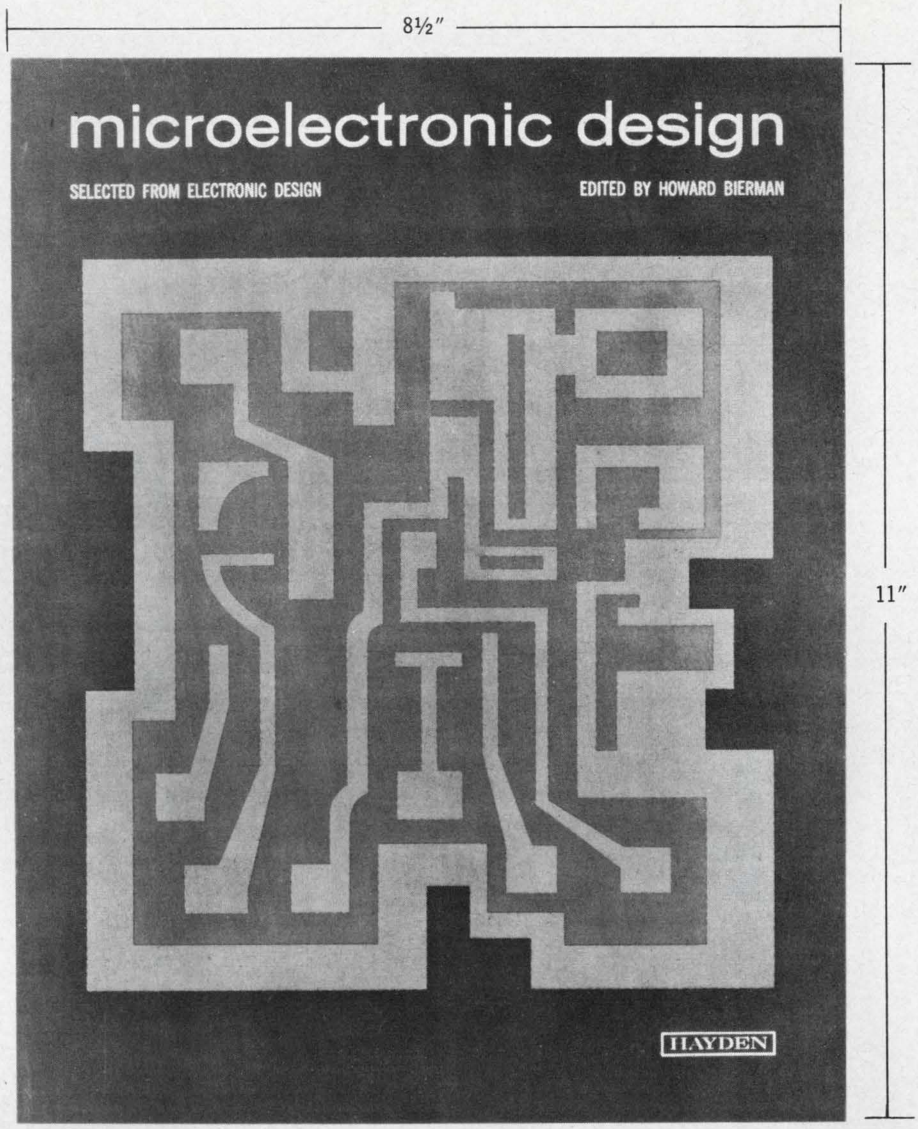
Wavetek, Inc

110 (FG-3)
111 (FG-4)
112 (FG-4)
114 (FG-3)
115 (FG-4)
116 (FG-4)
155 (FG-3)

Weinschel Engineering Co, Inc

MO-1C (SQ-1)

Manufacturers' addresses and literature offerings in master cross index at front of issue.



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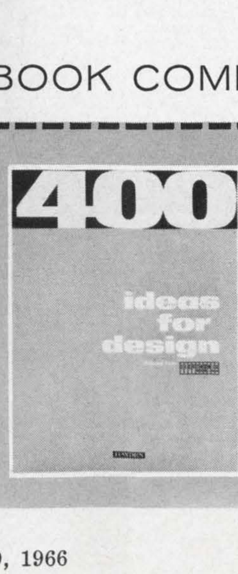

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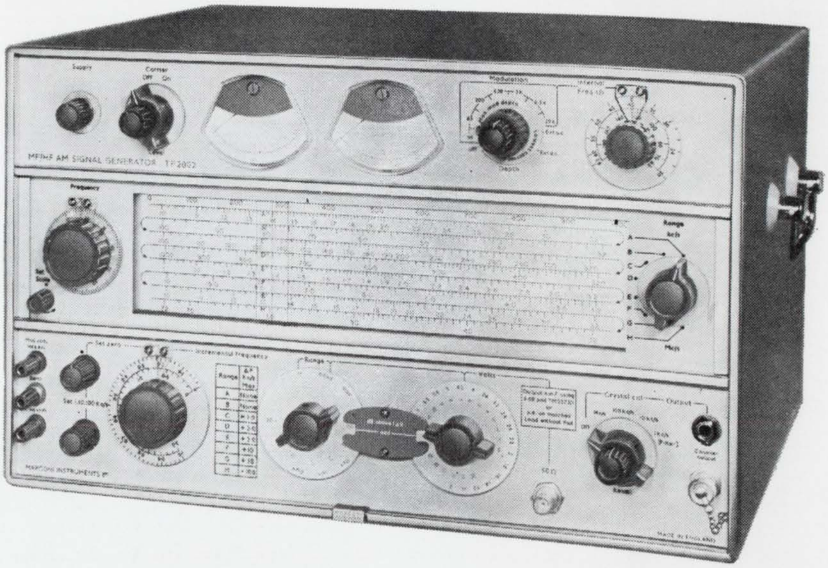

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2090	Noise Loading Test Set (Transistorized)	Up to 2700 Channels	204
7816	Twelve Channel Noise Generator	300 cps to 3400 cps for mux/demux	205
1313	¼% Universal Bridge	7 Decade Ranges LCR	206
Autospec	Telegraph Error Correcting Equipment	Up to 75 Bauds	207

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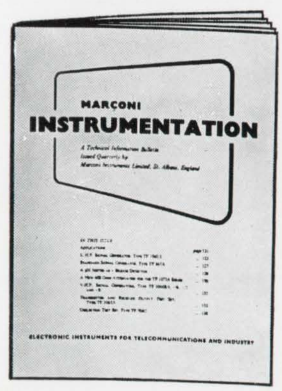

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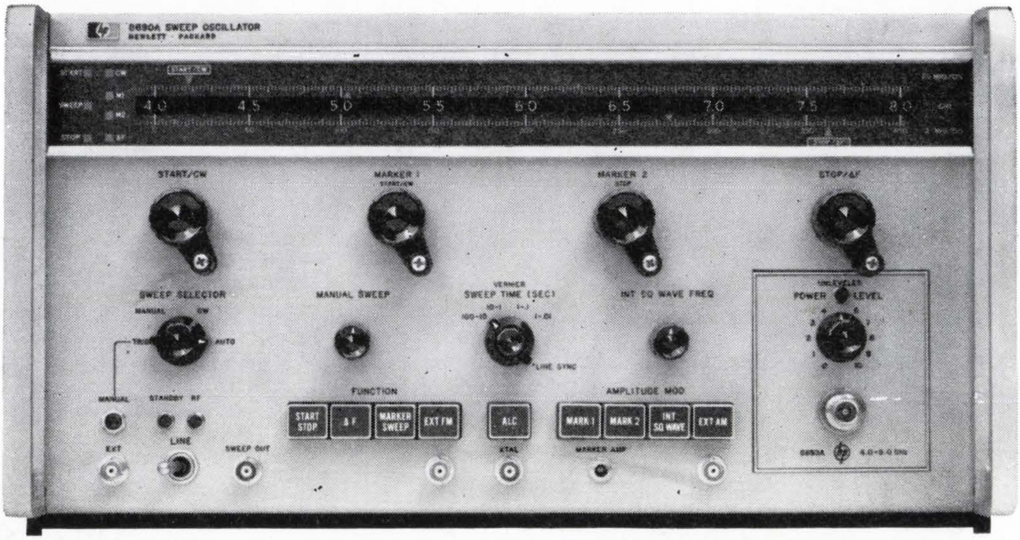

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8692B	2 - 4 GHz	≥ 40 mw	±10 MHz	1,975.00
H01-8692B	1.7 - 4.2 GHz	≥ 15 mw	±13 MHz	2,275.00
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8693B	4 - 8 GHz	≥ 15 mw	±20 MHz	1,900.00
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