the GENERAL RADIO
experimenter

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THE GR FAMILY OF SYNTHESIZERS IS GROWING....

in this issue:

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CONTENTS

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Figure 1. Panel view of the 12-Mc Synthesizer. Note the similarity to the 0.1-Mc and 1-Mc models shown above.

12-MC COHERENT DECADE FREQUENCY SYNTHESIZER

The GR family of frequency synthesizers now welcomes a new member, the 12-Mc TYPE 1163-A. Like its older brothers[1] it uses modular construction, which allows one to order at minimum cost the degree of resolution needed for one's application and also to add increased resolution later, if needed. Other features, common to the 1160 family, include 2-volt output, in-line readout, provision for sweeping, programmable options,[2] and ac or battery operation.

The TYPE 1163-A Coherent Decade Frequency Synthesizer, first displayed at the IEEE Show in March, is now in production. Using the same principles proved in the earlier instruments of the series,[1] it produces coherently synthesized sine-wave frequencies up to 12 Mc/s, selectable in 1-cycle steps. A continuous interpolation dial calibrated in 0.01-cycle divisions improves the resolution by at least two significant figures.

In appearance, the Type 1163-A closely resembles the TYPES 1161-A (100 kc/s , top frequency) and 1162-A (1 Mc/s), as illustrated in Figure 1. Like them, it is a frequency-coherent, beat-frequency oscillator, in which the two frequencies heterodyned to produce any chosen final output frequency are derived from a single, self-contained, 5-Mc, master crystal oscillator. Figure 2 shows in simplified form the basic principles of operation of all three types.

The final output of the TYPE 1163-A is at the difference frequency between

[1] Atherton Noyes, Jr., "Coherent Decade Frequency Synthesizers," *General Radio Experimenter*, September 1964.
[2] G. H. Lohrer, "Remote Programming for GR Synthesizers," *General Radio Experimenter*, May 1965.

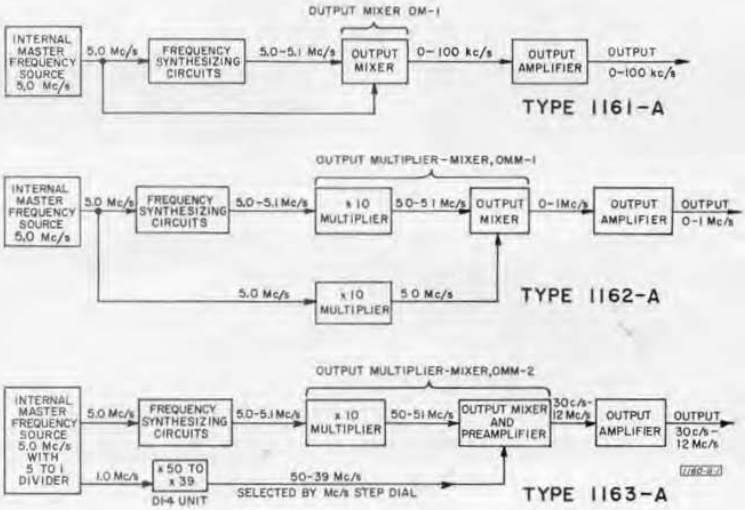


Figure 2. Block diagrams of the three GR synthesizers. All operate on the same principles and use interchangeable modules.

a signal synthesized anywhere in a continuous band from 50 to 51 Mc/s and a second signal generated, at 1.0-Mc increments, between 50 and 39 Mc/s, inclusive. The synthesized frequency between 50 and 51 Mc/s is produced in exactly the same way as in the 1-Mc Synthesizer[1], and all plug-in modules used in the direct synthesis of the 5- to 5.1-Mc band are identical and are readily interchangeable in synthesizers of all three types.

Two new modules are used in the 12-Mc Synthesizer — the TYPE 1163-DI-4 Digit-Insertion Unit, which develops steps of 1 Mc/s, and a new mixer, the TYPE 1163-OMM-2 Output Multiplier-Mixer.

The digit module generates the 1-Mc series from 50 to 39 Mc/s and has 12 positions, 0 through 11. Although it is is similar in size to the basic DI-1, the two are not interchangeable.

The mixer accepts at one end the 5/5.1-Mc synthesized signal from the DI-1 and CAD train; its second input, at 50 to 39 Mc/s as selected by the DI-4 dial, is mixed with a signal between 50 and 51 Mc/s produced in the unit by multiplication of the 5/5.1-Mc input by ten. It is noteworthy that the slight departure from the strict decimal system in the DI-4 unit — 12 numbered settings instead of 10 — gives a very useful extension beyond the normal 10-Mc decade limit, without the necessity for an additional digit unit.

Since the DI-4 performs an entirely different electrical function from any of the DI-1 units, the CAD cannot "replace" it in frequency, and, hence, no CAD pushbutton is provided for this position.

At the upper end of the output-frequency range the ratio of frequencies

[1] *Ibid.*
[2] *Ibid.*

applied to the output mixer is not so favorable to the suppression of spurious-frequency mixing products as it is in the lower-frequency synthesizers, and a low-level, more nearly square-law mixer is required. This mixer is followed by a broadband preamplifier (30 c/s to 12 Mc/s) and the final output amplifier.

The chassis of the TYPE 1163-A Synthesizer is superficially the same as that used in both the TYPE 1161-A and the TYPE 1162-A Synthesizers but differs in minor particulars. The two chassis are not interchangeable.

Except that there is no direct-coupled output provided, the operating controls and techniques are identical with those of the other members of the GR synthesizer family.

Continuously Adjustable Decade (CAD)

The Continuously Adjustable Decade (CAD) can replace any chosen group of DI-1 units in exactly the same way[1] as in the other instruments for search, sweep-frequency, or phase-tracking applications, and provisions for monitoring the CAD deviation from replaced dialed digits are identical. By means of the monitoring circuits, one can set the CAD precisely to three, or even more, significant figures, in terms of the digit dials.

Up to four DI-1 Digit-Insertion Units and the CAD can be omitted from any instrument, if not needed for the intended application, at a saving in initial cost, yet can be installed at any time. The rapid and easy interchange of modules between synthesizers also makes possible the transfer of digit units between instruments to suit the needs of the moment. All modules except the DI-4 Digit-Insertion Unit and the OMM-2 Mixer are identical with corresponding plug-in units in the other GR synthesizers and interchangeable with them.

Remote Programming

The RDI-1 Unit[2] can be plugged into any or all DI-1 digit stations in the TYPE 1163-A, just as in the other members of the family, wherever remote programming is required. At the present time a remotely programmable version of the DI-4 is not available.

Output Impedance Control

The screwdriver-operated switch near the output connection, which in the TYPE 1161-A/1162-A chassis selects between ac and dc output coupling, is used in the TYPE 1163-A to set the value of output impedance, after the point monitored by the panel voltmeter, at either 50 ohms or zero. When an impedance match to a 50-ohm load is not required, a voltage adjustable up to at least 2 volts, rms, will be delivered to a load of 50 ohms or higher when the switch is in the zero-ohm position. At the 50-ohm setting, 2 volts, rms, are available behind a 50-ohm matching resistor. The range of the output level control is at least 30 dB without instability of setting.

Receptacles at the Rear*

In this synthesizer, three BNC connectors are mounted at the rear of the instrument to give access to the synthesizer OUTPUT, the EXT CAD CONTROL input circuits, and the CAD deviation-

[1] *Ibid.*
[2] *Ibid.*

* The rear receptacles noted here are also incorporated in all current-production TYPES 1161-A and 1162-A Synthesizers.

monitoring BEAT terminals on the front panel. One additional subminiature receptacle, identified as 5/5.1 Mc/s REFERENCE, also is installed. This connects to the output of the pushbutton-replaced group of DI-1 units (group with dial illumination extinguished) for use in certain specialized applications.

At subminiature receptacles, which appear at the rear of the deck, other useful frequencies are available (see Specifications).

— ATHERTON NOYES, JR.

ACKNOWLEDGEMENTS

The present three GR synthesizers are the result of the combined efforts of G. H. Lohrer, C. C. Evans, W. F. Byers, and the author. In the TYPE 1163-A the primary responsibility for the new modules, the DI-4 and the OMM-2, was carried by Evans, who worked out an ingenious application of sampling techniques to the generation of the DI-4 output frequencies. Lohrer also contributed substantially to the new design, particularly in the output amplifier and mixer. Supporting effort by many other members of the General Radio organization, while well recognized and appreciated, has been too widespread to permit individual mention.

— A. N., Jr.

SPECIFICATIONS

Frequency Range: 30 c/s to 12 Mc/s.
Smallest Digital Step: 1 c/s.
Smallest Direct-Calibrated CAD Increment: 0.01 c/s.
Max Bandwidth Controllable by CAD: 1 Mc/s.
Spurious Frequency Outputs: Harmonic, < -34 dB; non-harmonic, < -60 dB.
Synthesizer Output: 0 to 2 V, metered, behind 50 Ω. 0 to 2 V, metered at output receptacle after low impedance.
Output-Frequency Characteristic: ± 1.5 db, max, 50 c/s to 12 Mc/s; 50-Ω load.
Output Terminals (at front-panel binding posts and at rear BNC connectors): Synthesizer OUTPUT, EXTERNAL CAD CONTROL, and BEAT.
Other Outputs (at rear connectors): 100 kc/s and 5 Mc/s (0.5 V, rms, min, across 50 Ω); 39 to 50 Mc/s in 1-Mc steps, 50 to 51 Mc/s, 5 to 5.1 Mc/s, 42 Mc/s (0.1 V min across 1 kΩ).
Operating Temperature Range: 0 to 50° C.
Internal Freqency Standard: Room-temperature, quartz-crystal oscillator. Temperature coefficient of frequency is typically less than 2×10^{-7}/°C from 20°C to 50°C. A front-panel frequency adjustment is provided. Crystal can easily be phase locked to an external standard.
Lock Signal Input from external standard (if used): 0.25 V, rms, to 5 V, rms, 5 Mc/s, or any submultiple down to 100 kc/s. Input impedance is approximately 1 kΩ for low-level signals; drops to approximately 50 Ω effective at high level.
Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 c/s, 55 W; or 20 to 28 V, dc, 1.8 A.
Accessories Supplied: TYPE 874-R22LA Coaxial Patch Cord, Bridging Unit (maintenance substitute for DI), Panel Insert for use with Bridging Unit, TYPE CAP-22 3-wire Power Cord, spare dial lamps and fuses.
Terminals: Locking GR874 coaxial, TYPE 938 Binding Posts, BNC, and miniature coaxial.
Cabinet: Rack-bench; end frames for bench mount and fittings for rack mount are included.
Dimensions: Bench model — width 19, height 5¼, depth 15½ inches (485 by 135 by 395 mm); rack model — width 19, height 5¼, depth behind panel 13 inches (485 by 135 by 330 mm).
Net Weight: 38 lb (17.5 kg).
Shipping Weight: 45 lb (20.5 kg).

MANUAL OPERATION

Catalog No.	*Type*	*Units Included*	*Price in USA*
1163-9597	1163-A7C	7 DI Units + CAD	$5600.00
1163-9596	1163-A6C	6 DI Units + CAD	5160.00
1163-9595	1163-A5C	5 DI Units + CAD	4720.00
1163-9594	1163-A4C	4 DI Units + CAD	4280.00
1163-9593	1163-A3C	3 DI Units + CAD	3840.00
1163-9417	1163-A7	7 DI Units	5100.00
1163-9416	1163-A6	6 DI Units	4660.00
1163-9415	1163-A5	5 DI Units	4220.00
1163-9414	1163-A4	4 DI Units	3780.00
1163-9413	1163-A3	3 DI Units	3340.00

REMOTE/MANUAL OPERATION

Catalog No.	*Type*	*Units Included*	*Price in USA*
1163-9527	**1163-AR7C**	1 DI+6 RDI Units+CAD	**$6110.00**
1163-9526	**1163-AR6C**	1 DI+5 RDI Units+CAD	**5585.00**
1163-9525	**1163-AR5C**	1 DI+4 RDI Units+CAD	**5060.00**
1163-9524	**1163-AR4C**	1 DI+3 RDI Units+CAD	**4535.00**
1163-9523	**1163-AR3C**	1 DI+2 RDI Units+CAD	**4010.00**
1163-9507	**1163-AR7**	1 DI+6 RDI Units	**5610.00**
1163-9506	**1163-AR6**	1 DI+5 RDI Units	**5085.00**
1163-9505	**1163-AR5**	1 DI+4 RDI Units	**4560.00**
1163-9504	**1163-AR4**	1 DI+3 RDI Units	**4035.00**
1163-9503	**1163-AR3**	1 DI+2 RDI Units	**3510.00**

THE GR SERIES OF SYNTHESIZERS

The presently available GR synthesizers, TYPES 1161-A, 1162-A and 1163-A, have digital frequency selection up to top frequencies of 100 kc/s, 1 Mc/s and 12 Mc/s, respectively. Each instrument, when fully equipped, has seven dials adjustable in digit steps and an eighth dial adjustable continuously. Since the maximum number of digit dials is fixed, it follows that the smallest available digit step increases in size as the available top frequency increases. Thus, the TYPE 1161-A has digit steps as small as 0.01 c/s, and the corresponding values for the TYPES 1162-A and 1163-A are 0.1 c/s and 1 c/s, respectively. For any application, therefore, the finest resolution can be obtained with the lowest-frequency model capable of covering the required range.

Also, the TYPE 1161-A has, in principle, ten times better phase stability and ten times smaller nonharmonic spurious outputs than the other two, as will be seen in the accompanying table of specifications. The TYPES 1162-A and 1163-A are nominally equal in these respects, so a choice between them can, in most cases, be made on the basis of range and resolution only.

The modular construction with interchangeable plug-in units yields a further advantage, which may influence the choice of synthesizers.

The TYPE 1161-A and the TYPE 1162-A can be transformed, each into the other, inexpensively, by the use of conversion kits comprising, principally, the output mixer modules. The 1160-3040 conversion kit ($295.00) will change a TYPE 1161-A into an 1162-A; for the reverse transformation, kit 1160-3030 is used ($155.00).

	Type 1161-A	**Type 1162-A**	**Type 1163-A**
Frequency Range:	0-100 kc/s	0-1 Mc/s	30 c/s-12 Mc/s
Smallest Digital Step:	0.01 c/s	0.1 c/s	1 c/s
Smallest Direct-Calibrated CAD Increments (A7C-models only):	0.0001 c/s	0.001 c/s	0.01 c/s
Max Bandwidth Controllable by CAD:	100 kc/s	1 Mc/s	1 Mc/s
RD1-1 Units may be used in:	All digit positions		All except 1-Mc step position
Spurious Frequency Outputs: Harmonic (at max output):	<-40 dB	<-40 dB	<-34 dB
Nonharmonic:	<-80 dB	<-60 dB	<-60 dB

COAXIAL MICROWAVE NEWS

- POWER DIVIDERS
- TERMINATIONS
- TIME-DOMAIN APPLICATIONS

The improved locking version of the GR874 basic connector, TYPE 874-BBL[1], now used on GR Coaxial Elements, has opened the way to broader frequency coverage and improved performance. Elements equipped with the new locking connector have a lower VSWR than formerly, over the extended frequency range of 0 to 9 GHz, with greater reliability and repeatability of connection. These elements are well suited for use in both frequency- and time-domain applications. The new locking connector is fully compatible mechanically with the earlier model, the TYPE 874-BL, and with the nonlocking, quick-disconnect, TYPE 874-B Connector.

The GR874 series of coaxial elements continues to offer high performance-per-dollar for a wide range of coaxial measurements. Low-VSWR plug and jack adaptors from the GR874 series to other coaxial connector types, both plug and jack, have broadened the scope of this series of elements to include almost all the popular 50-ohm connectors.

Two new elements using the -BBL Connector are a power divider and an improved 50-ohm termination. Both are also available in non-locking versions.

[1] "TYPE 874-BBL Connector," *General Radio Experimenter*, October 1965.

TYPES 874-TPDL and -TPD POWER DIVIDERS

Each of the TYPES 874-TPDL (locking) and -TPD (nonlocking) Power Dividers comprises a three-port coaxial tee that, throughout the frequency range, is nominally matched at any port when the remaining ports are terminated in 50.0-ohm loads. The broadband match is obtained by the use of three 16.67-ohm series resistors, one in each leg of the tee, and by careful compensation of the resistor surroundings. Figure 1 is a schematic diagram of the Power Divider. The insertion loss between any two ports, when the third port is connected to a matched termination, is nominally 6 dB.

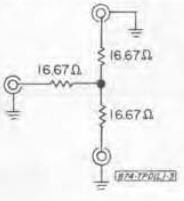


Figure 1. Simplified schematic of Power Divider.

These dividers utilize 1%, deposited-carbon-film resistors that combine high stability with high peak-power capac-

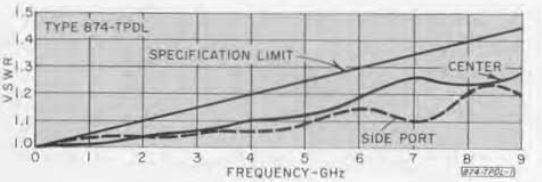
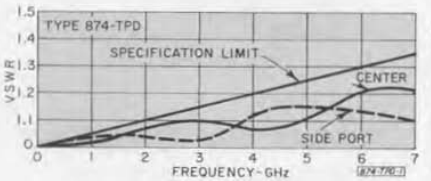


Figure 2. Typical VSWR characteristics.



ity. The film temperature coefficient is the order of −200 to −220 ppm/°C. The VSWR specifications (see Figure 2) provide a linear rise in VSWR with frequency at both the center and side ports of the tee.

Owing to the inherent symmetry, when the power divider is driven from the center port into equal loads, the output signals at the side ports are very nearly equal in amplitude and phase. Figure 3 shows the typical inequality of output signals in decibels.

The insertion loss between the center port and a sideport, with a matched source and matched load, deviates somewhat from 6 dB with increasing frequency owing to the distributed-impedance effects of the resistors at higher frequencies. Figure 4 shows the typical insertion loss for both types.

General Applications

The TYPE 874-TPDL/-TPD Dividers are used to split a signal into two approximately equal parts, with a minimum of reflections introduced in the process. When the divider is used to split the output of a nominally 50-ohm source between two 50-ohm loads, each load will be driven at a level 6 dB below the source output. Very little of the source signal is reflected at the power-divider input owing to the low input VSWR. Any signals reflected from the loads are isolated, by the 6-dB insertion loss of the power divider, from each other and from the source. Re-reflections at the divider outputs are small, again owing to the low divider standing-wave ratio.

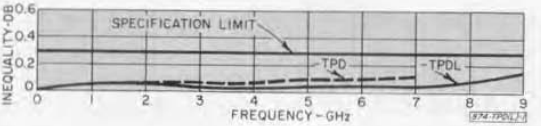


Figure 3. Typical inequality of output signals at side ports.

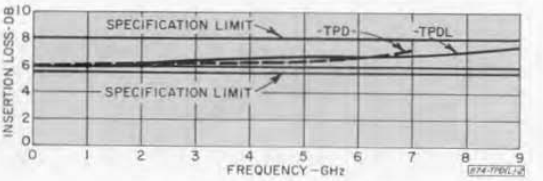


Figure 4. Typical insertion loss between center and side ports.

These dividers are also used (usually in conjunction with some additional isolation devices such as GR874 Attenuators) to combine two signals. In this case, the two source signals are isolated from each other by the divider insertion loss and any additional padding. The sum of the two applied signals appears at the common port of the divider.

Applications are found in antenna-feed systems, in dual-channel insertion-loss or phase-measuring systems, and in pulse systems. The applications to the last area are discussed in greater detail on page 12.

SPECIFICATIONS

TYPE 874-TPDL POWER DIVIDER

Frequency Range: dc to 9 GHz.
Characteristic Impedance: 50 Ω, nominal.
VSWR (at any port when remaining ports are terminated in matched 50-Ω loads): Less than $1.00 + 0.05 \times f_{GHz}$ to 9 GHz.
Inequality of Power Division (symmetrically fed): Less than 0.3 dB.
Phase Difference between Outputs (symmetrically fed): 0°, nominal.
Insertion Loss (between any two ports when remaining port is terminated in a matched 50-Ω load): 6 dB, nominal.
Insertion Loss (input to each output, symmetrically fed): $6.0\ ^{+2.0}_{-0.5}$ dB.
Dc Resistance (at any port, when remaining ports are terminated in 50.00-Ω resistors): 50.00 ± 0.25 Ω (0.5%).
Maximum Input Power: 2 W, continuous.
Dimensions: Width 4, height $2\frac{3}{16}$, depth $1\frac{1}{16}$ inches (105 by 60 by 27 mm).
Net Weight: 6 ounces (170 grams).

Catalog Number	*Description*	*Price in USA*
0874-9913	**Type 874-TPDL Power Divider**	**$73.00**

U.S. Patent No. 2,548,457

TYPE 874-TPD POWER DIVIDER

Same as Type 874-TPDL, except:
Frequency Range: 0 to 7 GHz.
VSWR (at any port when remaining ports are terminated in matched 50-Ω loads): $1.00 + 0.05 \times f_{GHz}$ to 7 GHz.
Dimensions: Width 4, height $2\frac{3}{16}$, depth $1\frac{3}{16}$ inches (105 by 60 by 20 mm).
Net Weight: 5 ounces (145 grams).

Catalog Number	*Description*	*Price in USA*
0874-9912	**Type 874-TPD Power Divider**	**$70.00**

U.S. Patent No. 2,548,457

TYPES 874-W50BL and -W50B 50-OHM TERMINATIONS

New 50-ohm terminations, the TYPES 874-W50BL and −W50B, now replace the TYPES 874-W50L and −W50. In these new terminations the design of the resistor surroundings has been improved,[2] and the TYPE 874-W50BL is equipped with the new TYPE 874-BBL Connector.

Figure 5 shows the VSWR specification, as well as the performance of a

[2] MacKenzie, T. E., "Recent Advances in the Design of Precision Coaxial Standards and Components," *1965 IEEE Convention Record*, Part 5, Session 67, p 190.

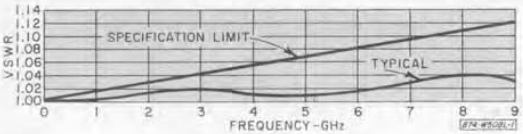


Figure 5. Type 874-W50BL Termination VSWR.

typical unit, for the TYPE 874-W50BL; Figure 6 shows similar curves for the TYPE 874-W50B, which is equipped with the non-locking connector, TYPE 874-B.

The terminating element used in both units is a highly stable, deposited-metal-film resistor with a dc resistance of 50.0 ohms ±0.3% and a temperature coefficient of less than 150 ppm/°C. The change in resistance and VSWR versus heating due to incident power is negligible up to 1 watt. The resistors can dissipate up to 5 watts incident power without permanent change of characteristics.

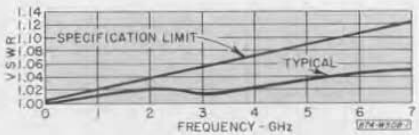


Figure 6. Type 874-W50B Termination VSWR.

General Applications

The TYPE 874-W50BL/-W50B Terminations are used as standards in the calibration of bridges, slotted lines, and reflectometers and as reference terminations in measurements of multiport networks. They are well suited for use with the TYPE 874-LBA Slotted Line as a termination for impedance measurements of multiport networks equipped with GR874 Connectors. Through the use of GR874 Adaptors, these terminations can be used as dummy loads in other line sizes. Their use in time-domain applications is discussed below.

SPECIFICATIONS

TYPE 874-W50BL 50-OHM TERMINATION

Frequency Range: dc to 9 GHz.
VSWR: Less than $1.005 + 0.013 \times f_{GHz}$.
Dc Resistance: 50.0 ohms ±0.5%.
Maximum Power: 2 watts, continuous (1 watt with negligible change in resistance and VSWR; 5 watts without damage).
Dimensions: Length, 2¼ inches (57 mm); maximum diameter, 1 1/16 inches (27 mm).
Net Weight: 3 ounces (85 grams).

Catalog Number	*Description*	*Price in USA*
0874-9955	**Type 874-W50BL 50-ohm Termination**	**$24.00**

U.S. Patent No. 2,548,457

TYPE 874-W50B 50-OHM TERMINATION

Same as Type 874-W50BL, except:
Frequency Range: dc to 7 GHz.
VSWR: less than $1.005 + 0.017 \times f_{GHz}$.
Dimensions: Length, 2¼ inches (57 mm); maximum diameter, 13/16 inch (20 mm).
Net Weight: 2½ ounces (70 grams).

Catalog Number	*Description*	*Price in USA*
0874-9954	**Type 874-W50B 50-ohm Termination**	**$23.00**

U.S. Patent No. 2,548,457

TIME-DOMAIN APPLICATIONS OF COAXIAL ELEMENTS

The GR874 series of coaxial elements — connectors, air lines, tees, terminations, etc, are widely used in pulse-system measurements. In these time-domain applications they offer high performance at low cost, and their hermaphroditic-mating and quick-disconnect features help to save both time and money.

With the advent of fast-rise-time, gigahertz-pulse generators and sampling oscilloscopes, emphasis has been put on the high-frequency performance of coaxial elements. Here again the

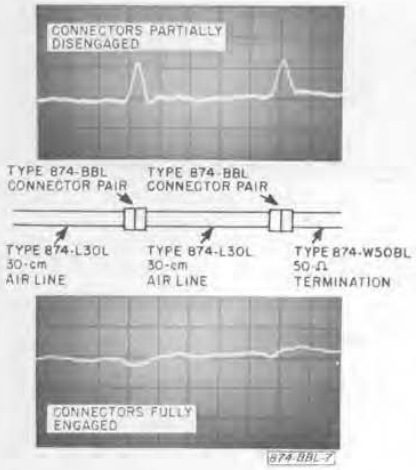


Figure 7. Time-domain reflectometer traces. Vertical scale: Reflection coefficient = 0.005/cm. (Z_0, normalized to 50 ohms, 1%/cm.) Horizontal scale: 6 cm of line/cm.

broad line of GR874 coaxial elements provides the required performance characteristics.

Bandwidth and pulse rise-time are related approximately by $bw = 0.35/rt$. Thus, the typical fast pulse characterized by a 100-ps rise-time corresponds to a bandwidth of about 3500 MHz. To keep pulse distortion and reflection low, it is necessary to keep the VSWR of the associated coaxial circuitry low over the full bandwidth of the pulse. The new GR874 Coaxial Elements meet this need. For example, the TYPE 874-TPDL Power Divider introduces a VSWR of less than 1.18 up to 3500 MHz while the TYPE 874-W50BL Termination VSWR is less than 1.05 up to 3500 MHz.

The advantages of GR874 elements for handling fast-rise-time pulses are further illustrated by time-domain reflectometer traces.

Figure 7 shows time-domain reflectometer traces of two TYPE 874-L30L Air Lines connected in series and terminated in a TYPE 874-W50BL. All connectors are the new TYPE 874-BBL Locking Connectors. To obtain the upper trace, the connector joints were partially disengaged in order to pin point their locations. For the lower trace, the connectors were fully engaged; characteristic impedance variations throughout the air line, connector, and termination sections are less than 0.5%.

Sampling Oscilloscope

Reflectometer

Figure 8 illustrates the use of the TYPE 874-TPDL/-TPD Power Divider in time-domain reflectometry instrumentation built around a sampling scope.[3,4,5] The power divider transforms the pulse generator into a nearly matched source, thereby reducing troublesome re-reflections, even in the presence of large reflections from the unknown.

The air line provides time isolation between the source and the unknown impedance reference. The characteristic impedance of the TYPE 874-L Air Lines

[3] Long, Gordon D., "Pulse Reflections Pin Down Discontinuities," *Electronic Design*, May 10, 1963, pp 62-66.
[4] Noel, D. K., "Subnanosecond Instrumentation," *IEEE Student Journal*, January 1964, pp 27-32.
[5] Application Note 62, "Time-Domain Reflectometry," Hewlett-Packard Company, 1964.

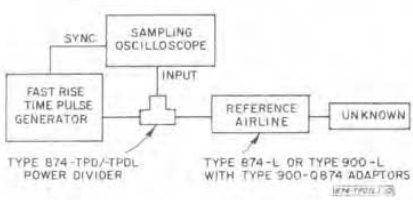


Figure 8. Use of the Type 874-TPDL/-TPD Power Divider in time-domain reflectometry instrumentation built around a sampling oscilloscope.

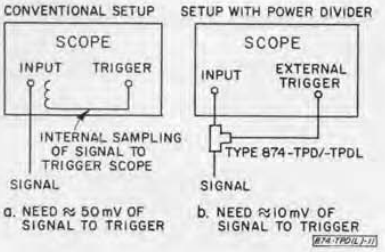


Figure 9. Use of the Type 874-TPDL/-TPD Power Divider to increase the sensitivity of sampling oscilloscopes.

is 50.0 ohms ±0.4%. The characteristic impedance of the TYPE 900-L Air Line, which can be used with TYPE 900-Q874 Adaptors to the GR874 line size, is 50.0 ohms ±0.065%.

TYPE 874-W50BL/-W50B Terminations keep reflections low at the output ports of multiport unknowns.

Trigger

Sampling-oscilloscope sensitivity can often be increased by a factor of five if a power divider is used in the signal-input line. The performance improvement is brought about by external division of the signal to increase the trigger input. Thus, a representative sampling oscilloscope that requires a 50-millivolt signal to provide 5 millivolts of trigger internally can trigger equally reliably on input signals of only 10 millivolts, when the power divider is used. Figure 9 shows this principle.

Pulser Accessories

The repetition rate of most fractional nanosecond-rise-time pulse generators can be extended from several hundred hertz to the region of several hundred megahertz by cascaded power dividers. As shown in Figure 10, power dividers can be cascaded to fractionize the original pulse, and additional dividers can be used to recombine the resulting signal, after suitable delays, into a train

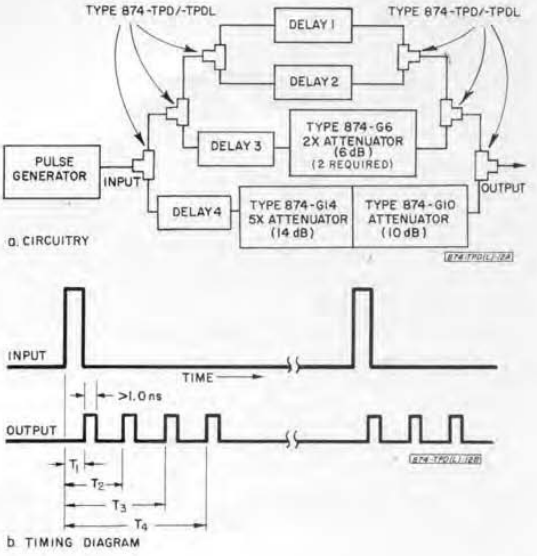


Figure 10. Cascaded power dividers used to construct a pulse burst, which effectively raises the repetition rate of a subnanosecond-rise-time pulse generator to several hundred megahertz.

of pulses, adjustably spaced in times T_1 through T_4.

This application envisions as a pulse generator one that consists of a 50-ohm charge line operated with a mercury-wetted reed switch.

GR874 Air Lines can be used for minute delays (up to 1 ns), and GR874 Attenuators are available to achieve compensatory losses, where required, for pulse bursts of uniform amplitude.

The TYPE 874-G6 (6 dB or 2×) Attenuator bears the most convenient relation to the insertion loss in the divider.

Patch cords, ells, adaptors, and other elements needed to complete the system are available.

— THOMAS E. MACKENZIE

Credits

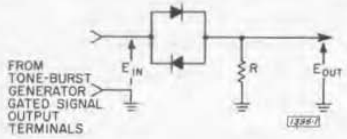
The writer gratefully acknowledges the contributions of time-domain applications of the GR874 elements provided by J. K. Skilling and D. S. Nixon, Jr. of the GR engineering staff.

MEASUREMENT BRIEFS

A Note on the Tone-Burst Generator Reduction of Gate Feedthrough

Some users of the TYPE 1396-A Tone-Burst Generator may require a ratio of open- to closed-gate signal greater than the 40 dB we specify (43 dB typical). It is not possible to modify the design of the instrument in this respect without sacrificing switching-noise suppression and gate speed (maximum frequency).

Addition of the circuit shown below, however, can reduce the feedthrough by introducing a small amount of distortion in the output. This circuit is an attenuator for small voltages (less than ±1 volt), and it passes other voltage levels with little attenuation. Since feedthrough is in the ±1-volt range, it is attenuated, but the desired signal (assumed at maximum level of ±7 volts) has only a small amount of distortion near the zero crossings. This distortion looks much like crossover distortion and may be quite acceptable in some applications.



With germanium diodes, 1N455-type, and a value of R of 1.0 kilohm, the feedthrough varies from −55 dB at 500 kc/s to −58 at 20 kc/s and below. With silicon diodes, 1N459A-type, and a value of R of 10 kilohms, the feedthrough drops to −63 dB at 500 kc/s, −77 dB at 20 kc/s, and less than −80 dB at 2 kc/s and below. The silicon diodes, however, introduce more distortion than the germanium diodes. By the addition of bias sources in series with the silicon diodes it should be possible to effect a compromise between distortion and attenuation of feedthrough.

— J. K. SKILLING

Instrument Note on Frequency Converter

The TYPE 1133-A Frequency Converter[1] extends the range of 10-Mc counters to 500 Mc/s. Originally designed for use with GR counters, it can also be operated with counters of other manufacture. Details of this use are discussed in a recently published Instrument Note, free on request. Ask for IN-106.

[1] H. T. McAleer, "A New Converter for Frequency Measurements to 500 Mc," *General Radio Experimenter*, December, 1962.

Capacitance Change Measures Strain in Fibers

A recent article[1] in *The Review of Scientific Instruments* describes a new testing device for inorganic whiskers and other fine fibers, developed by the Laboratory for Physical Science of P. R. Mallory and Company at Burlington, Mass. The fiber-holding device replaces one pan of an analytical balance. Measurable stress can be applied by weight in the other pan. Flat electrodes on the holder form the plates of a capacitor, whose capacitance changes with changes in length of the fiber under test.

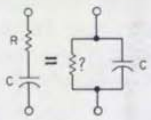
The capacitance change is measured with a GR TYPE 1615-A Capacitance Bridge, which is capable of detecting a change of 1×10^{-17} F.

[1] R. H. Kelsey and R. H. Krock, "Microfiber Stress-Strain Apparatus," *The Review of Scientific Instruments*, 36, 7, July 1965, pp 1031–1034.

Photo courtesy Electro Dynamic Division, General Dynamics.

In this console, used in tests on motor-generator sets, GR sound-level meters, analyzers, and recorders measure air-borne sound and automatically record the frequency spectra of structure-borne vibrations. Electro Dynamic at Avenel, N. J., manufactures heavy electrically operated equipment, including ac and dc motors, generators, blowers and fans, frequency converters, and HERF machines.

OUR ABACUS SLIPPED A COLUMN



The less-than-perfect arithmetic on page 12 of our July issue has recently been called to our attention. We had hoped it would be overlooked. Mr. P. K. McElroy, author of the article in question, cannot be held responsible, since he retired from the General Radio Engineering Staff a full six months before the article was published, and, further, these figures were not in his original article. For the record, however, an editorial apology to him and a published correction are in order. Thus—to Mr. McElroy, our regrets for having, by implication, attributed to him the faulty calculations, and, for the record, these are the ohms:

0.0016 ohm should be 0.016 ohm

16 ohm should be 160 ohm

26 ohms should be 13 ohms.

Fortunately for the unidentified toiler who perpetrated these errors, the corrections in no way alter the conclusions drawn in the article.

GENERAL RADIO COMPANY EXTENDS TO ALL EXPERIMENTER READERS ITS BEST WISHES FOR A HAPPY AND PROSPEROUS 1966

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