OPERATING INSTRUCTIONS

TYPE 874-GAL ADJUSTABLE ATTENUATOR

DESCRIPTION

The Type 874-GAL Adjustable Attenuator is of the wave-guide-below-cutoff type operating in the $TE_{1,1}$ mode (inductive coupling). The waveguide is excited by a coaxial transmission line, as shown in Figure 1, and the output voltage is induced in a loop mounted on a sliding plunger. One end of the loop is terminated in a 50-ohm resistor and the other is connected to the output cable. This arrangement makes the output impedance of the attenuator approximately 50 ohms. The attenuation is varied by rotating the barrel which moves the plunger and loop along the tube. The barrel is calibrated in relative attenuation in dB. The attenuators can be adjusted from the stop at the minimum attenuation position, which occurs at about -9 dB on the calibrated scale, to the stop at the maximum attenuation end of the range, which occurs at about 140 dB on the scale. Each revolution of the barrel changes the attenuation 20 dB. In most applications the maximum usable attenuation is limited by leakage from various parts of the driving circuit and not by the range of the attenuator. In this type of variable attenuator, as the attenuation is varied the phase at the output connection is essentially constant with respect to the input signal phase.

The method of coupling to the coaxial line permits the attenuator to be used as a standard calibrated attenuator or as a device to couple a small amount of energy from a high-level circuit for monitoring or measuring purposes without introducing a large discontinuity in the main line.

The Type 874-GAL Coaxial Attenuator employs the new Type 874-BL Locking Coaxial Connectors. These connectors can be used interchangeably with the standard GR874® Connectors. When mated with another locking connector, a firm mechanical coupling of the two is achieved when the coupling shell is engaged. The shielding is also improved significantly, and, in general, the leakage is reduced by at least 50 dB.

The "quick-disconnect" feature of the standard GR874 Coaxial Connectors is retained in the locking type if the coupling shell is not engaged. However, in this case the shielding is not as effective.

ERRORS

In all waveguide attenuators, the excitation of modes other than the desired one distorts the theoretical attenuation characteristic, particularly at low attenuation levels. In the Type 874-GAL Attenuator, the $TM_{0,1}$ mode (capacitive coupling) is the most serious offender. This mode is attenuated more rapidly with distance from the source end of the waveguide than is the desired mode and its intensity is proportional to the voltage across the exciting line at the coupling point, while the intensity of the desired mode is proportional to the current flowing in the exciting line at the point of coupling. The effect of the undesired mode on the attenuation characteristic therefore decreases as the attenuation increases. Since the output from the attenuator is the sum of the voltage generated in the loop by both modes, serious errors can result if the voltage in the exciting line at the coupling point is high compared to the current; that is, if the impedance is high. An error correction procedure is required to achieve the stated accuracy for the 874-GAL Attenuator.

CORRECTION PROCEDURES

There are two configurations that may be employed in using the 874-GAL. First, it may be terminated in a 50-ohm termination (874-W50BL) as shown in Figure 2, in which case the special correction given in Figure 2 is required, and, in addition, the frequency correction of Figure 3 is required. In the second configuration recommended to achieve the best accuracy above 2 GHz, the termination is an adjustable stub employed to place a voltage minimum at the coupling points. The frequency correction graph of Figure 3 is required only in this case. The detailed procedure is given in the following paragraphs.

If the exciting line is terminated in its characteristic impedance, for instance with a Type 874-W50BL Termination, the error resulting from the coupling of the $TM_{0,1}$ mode can be corrected by using the correction chart of Figure 2. The sign of the correction depends on which end of the exciting line is connected to the source of rf power. If the source is connected to the end marked with the letter S, use the correction curve labeled NORMAL and subtract the correction found for initial setting of the attenuator from the initial scale reading. Then subtract the correction found for the final setting of the attenuator from the final scale reading. The true attenuation is the difference in the corrected values. If the source is connected to the opposite end, add to the indicated values the corrections read from the curve labeled REVERSED. When these correction charts are used, the indicated relative attenuation is accurate within ±(0.015 times the difference +0.2)dB at frequencies up to 2000 MHz. For accurate results at higher frequencies for small values of attenuation, the method outlined in the following paragraph should be used.

To eliminate the correction and to make the indicated relative attenuation agree very closely with the actual attenuation between -9 and 140 dB on the scale, the voltage across the line, at the actual coupling point, should approach zero. To accomplish this, connect an adjustable short-circuiting stub (Type 874-D20L or -D50L) to the end of the main line opposite the source. Adjust the stub until a voltage minimum appears at the coupling point. To find this stub adjustment, substitute a Type 874-VRL Voltmeter Rectifier and a Type 874-VI Voltmeter Indicator, or a Type 874-TL Tee and a detector, for the attenuator. Adjust the stub until the indicated voltage is minimized; then replace the attenuator. (If the Type 874-VRL is used, connect the end containing the series resistor, engraved R, to the generator.) If the frequency is changed the stub must be reset, but a frequency calibration can be marked on the stub, for convenience when a number of measurements are to be made. At frequencies below 300 MHz, a Type 874-WNL Short Circuit can be substituted for the stub, without further adjustments. With the Type 874-WNL Short Circuit, accurate results can be obtained at scale readings greater than zero. At frequencies below 1500 MHz, the indicated attenuation is accurate at scale readings as low as -9 dB, and, at frequencies between 1500 and 4000 MHz, readings above 0 dB on the calibrated scale are accurate if the stub is set as previously outlined.

An alternate method of setting a voltage minimum at the coupling point, for frequencies above 1500 MHz, utilizes the fact that the attenuation constant for the desired mode is smaller than that of the spurious modes. If the attenuator is set to a relatively large value of attenuation, the stub can be properly set by adjusting it until maximum output is obtained from the attenuator. However, a voltage minimum does not occur at the coupling point unless the effective source impedance, seen looking back toward the generator from the coupling point, is a pure resistance. When the generator and the detector are not matched, the above condition can be obtained by the use of suitable pads (Type 874-G10L or -G20L) at the generator and the detector.

At the higher frequencies the attenuation is reduced as the waveguide approaches its cutoff frequency. To correct for this effect, multiply the indicated attenuation by the factor found in the frequency correction graph, Figure 3, corresponding to the operating frequency.

The impedance of the adjustable arm of the attenuator is nominally 50 ohms. However, the impedance varies appreciably with frequency, as shown by the plot in Figure 4 of the VSWR seen looking back into the output connector for a typical unit. The tolerance on the dc resistance of the 50-ohm resistor is ±10%.

APPLICATIONS

(1) The attenuator can be used with a Type 874-VR or -VRL Voltmeter Rectifier and a Type 874-VI Voltmeter Indicator to provide the level-monitor and variable attenuator of a signal generator, when combined with a General Radio Oscillator. The Types 1362, 1363 and 1218 are recommended. A block diagram of a typical setup is shown in Figure 5.

In this case the stub is adjusted as indicated in a previous paragraph and the adjustable line[1] (Type 874-LAL) is adjusted to obtain a maximum indication from the Type 874-VI Voltmeter Indicator. The voltage indicated with the load connected is the effective open-circuit output voltage, and the source impedance is accurately 50 ohms. The output can be reduced by adjusting the attenuator; the actual voltage at any attenuator setting is the indicated number of db below the original calibrating value.

Since the source impedance is the same as the characteristic impedance of the line, the same effective open-circuit voltage and source impedance are obtained at the end of any length of 50-ohm line connected to the output of the voltmeter rectifier. If the line is not lossless, the effective open-circuit voltage will be reduced by the loss in the line.

(2) The attenuator can also be used to measure the attenuation of a network by the substitution method, as indicated by the block diagram in Figure 6.

Readings of the detector output and attenuator setting are first made without the circuit under test connected. The circuit is then inserted and the Type 874-GAL Adjustable Attenuator is readjusted to give the same detector indication. The attenuation of the unknown circuit is then the difference in the attenuator readings. The pads indicated are used to make the source and load impedances very close to 50 ohms. One or both can be omitted if the source and detector impedances are matched.

(3) For monitoring purposes the input line of the attenuator can be connected in series with the line under test without introducing an appreciable reflection or loss. The changes in level in the main line can be measured accurately using the attenuator and an uncalibrated detector which may be 1) a Type 874-VRL Voltmeter Rectifier with a dc microammeter or an audio amplifier such as the General Radio Type 1232-A Tuned Amplifier and Null Detector if the signal is modulated or 2) if the signal is not modulated, the General Radio Type 1241 Heterodyne Detectors may be

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[1]At the lower frequencies, it may be necessary to add lengths of Type 874-L30 Air Line in series with the adjustable line to obtain the maximum output.

employed. The VSWR introduced in a flat line by the insertion of the attenuator is shown in Figure 7.

(4) It can be used as a phase inverter if the flexible leg is driven, producing equal outputs 180° out of phase at the remaining legs.

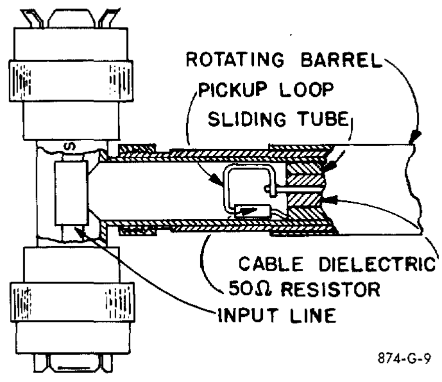

Figure 1. Cutaway view of adjustable attenuator.

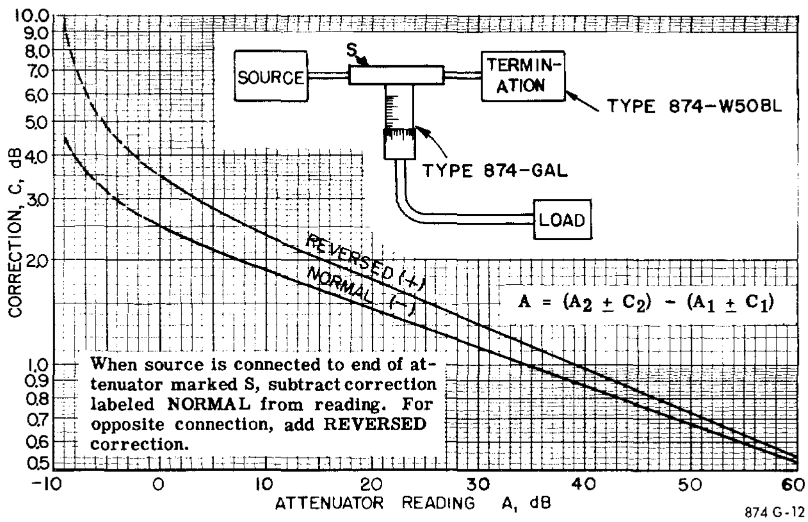

Figure 2. Correction chart for use with Type 874-GAL Adjustable Attenuator when exciting line is terminated in its characteristic impedance.

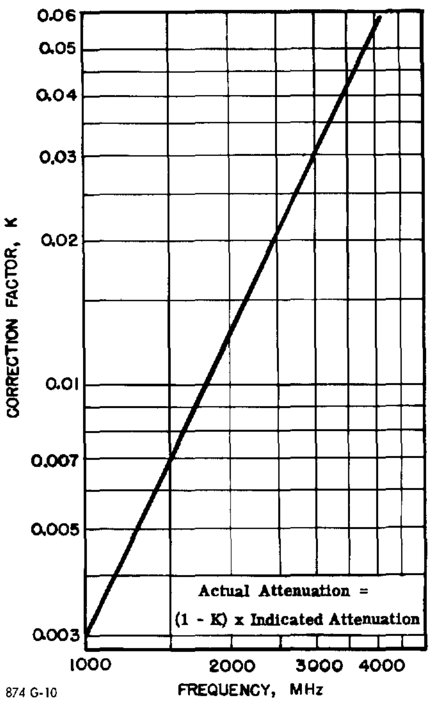

Figure 3.
Frequency Correction Factor.

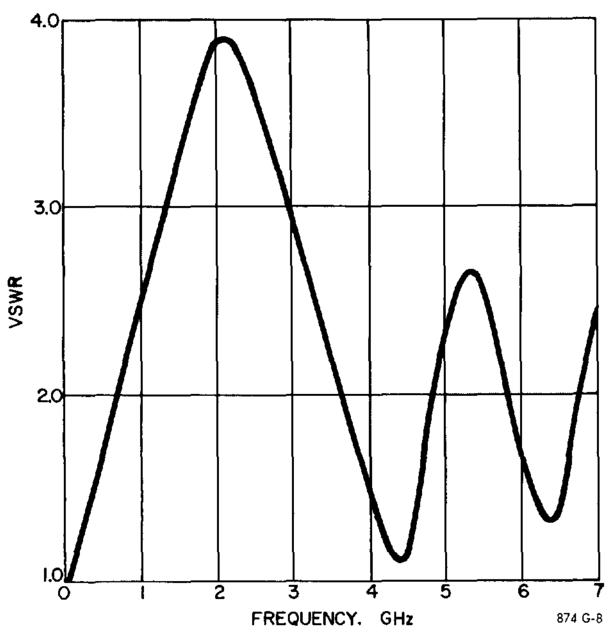

Figure 4.
VSWR seen looking back into output connector of a typical Type 874-GAL Adjustable Attenuator.

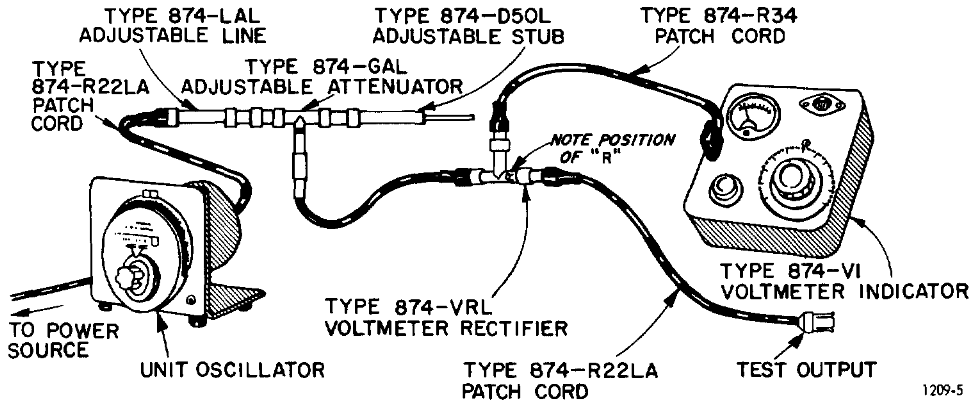

Figure 5. Block diagram of a simple signal generator using the adjustable attenuator and other GR874 Coaxial Elements.

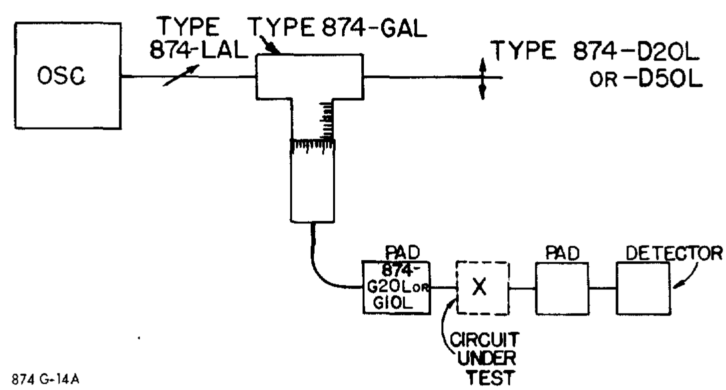

Figure 6. Block diagram of setup for measuring the attenuation of a network.

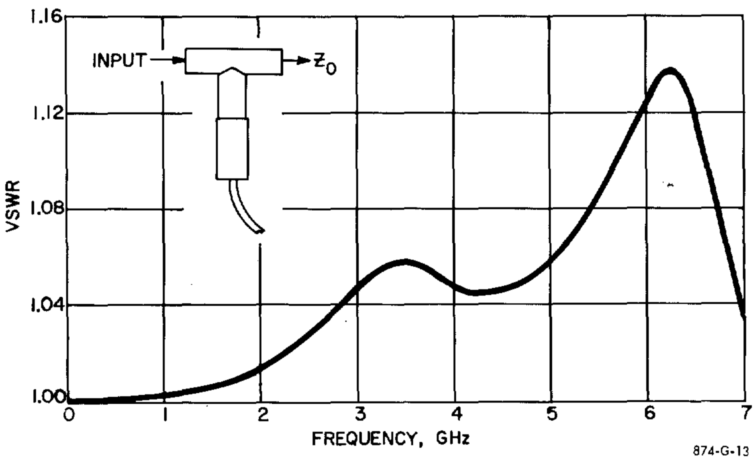

Figure 7. VSWR introduced in a flat line by the insertion of a Type 874-GAL Adjustable Attenuator.

SPECIFICATIONS

A waveguide-below-cutoff type, useful as a calibrated attenuator or as a sampling device. Calibrated in decibels, on a micrometer-type scale. Absolute attenuation is the sum of insertion loss and scale reading. Phase shift is essentially constant as attenuation is varied. The main line is a short coaxial section with locking GR874 connectors, one end for source, the other for load. It introduces minimum discontinuity when inserted in a 50-ohm line. The loop output is brought out through three feet of 50-ohm cable with locking GR874 connector.

Calibrated Range: 120 dB (relative attenuation) with input line terminated in 50 Ω; 129 dB with input line terminated in adjustable stub to minimize the electric field at the coupling point (scale reads −9 to 120 dB).

Insertion Loss (from input connector to end of output cable at 1 GHz, when signal source impedance is 50 Ω):
With input line terminated in 50 Ω, and scale set at 0 dB, 30.4 dB ±2 dB; **set at −9 dB,** 17 ±2 dB (settings below 0 are not accurate).

With input line terminated in adjustable stub (which extends the range over which the calibration is accurate to the −9 dB scale setting), 19 ±2 dB minimum.
(Insertion loss is approximately inversely proportional to frequency up to 1 GHz.)

Insertion Loss Directly Through Tee: Negligible.

Accuracy of Attenuation:
Stub-terminated input, ±(0.01 times difference in attenuation reading +0.2) dB, direct-reading.
50-Ω terminated input, ±(0.015 times difference in attenuation reading +0.2) dB, when corrected. Correction chart supplied.

VSWR Introduced into Line: <1.03 at 1 GHz; <1.12 from 1 to 4 GHz.

VSWR of Output: <4 at 1 GHz; <5 from 1 to 4 GHz.

Max Power: Input power limit inversely proportional to square root of frequency. Power should not exceed 300 W at 1 GHz. Output power should not exceed ½ W.

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