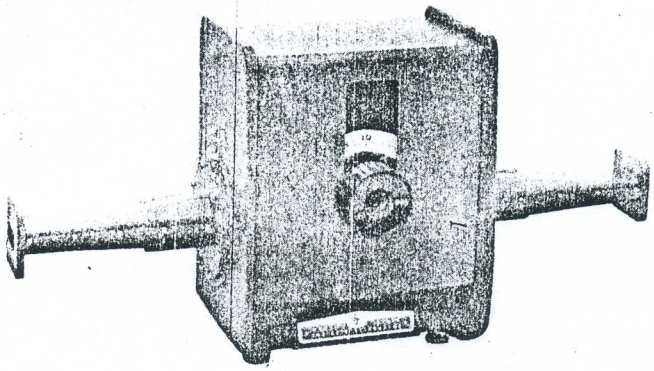
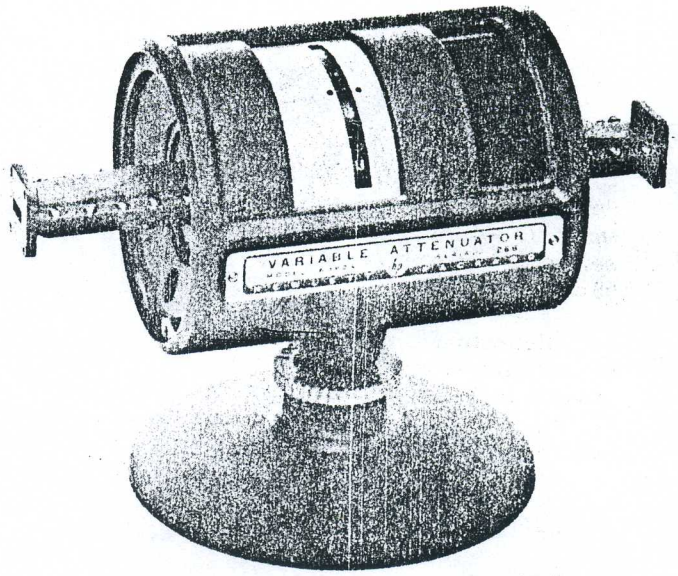
OPERATING NOTE

VARIABLE ATTENUATORS

382A



H, X and P382A
G and J have round flanges



M, K and R382A

HEWLETT hp PACKARD

Table 1. Specifications

Model	Frequency Range (GHz)	Fits Waveguide Size (in.)	Fits Waveguide Size (EIA)	Flange UG	Power Capacity*	Length (in.)	Length (mm)	Height (in.)	Height (mm)	Depth (in.)	Depth (mm)	Weight (lb)	Weight (kg)
G382A	3.95-5.85	2 x 1	WR187	407/U[3]	15	31-5/8	803	9-5/8	245	7-3/4	197	25	11, 3
C382A	4.7-7.05	1.718 x 0.923	WR159	CRM-159	10	23-1/8	587	7-7/8	200	6-3/16	157	13	5, 8
J382A	5.3-8.2	1-1/2 x 3/4	WR137	441/U[3]	10	25	635	7-7/8	200	6-3/16	157	13	5, 8
H382A	7.05-10.0	1-1/4 x 5/8	WR112	138/U	10	20	508	7-15/16	202	6-1/2	165	10	4, 5
X382A	8.2-12.4	1 x 1/2	WR90	135/U	10	15-5/8	397	7-5/8	194	4-11/16	119	5	2, 3
M382A	10.0-15.0	0.850 x 0.475	WR75	Cover (A1)	10	13-7/32	336	5-1/2	140	5-1/2	140	4	1, 8
P382A	12.4-18.0	.702 x .391	WR62	Cover (A1)	5	12-1/2	318	7-3/4	197	4-3/4	121	5	2, 3
K382A[1]	18.0-26.5	1/2 x 1/4	WR42	597/U	2	7-5/8	194	6-1/8	156	4-3/4	121	3.5	1, 6
R382A[2]	26.5-40.0	.360 x .220	WR28	Cover (A1)	1	6-3/8	162	6-1/8	156	4-3/4	121	3.5	1, 6

Calibrated Attenuation Range: 0 - 50 dB (above insertion loss).
Phase Shift: Variation less than 3° from 0 to 50 dB.
SWR: Less than 1.15 over entire range of attenuation and frequency.
Accuracy: ±2% of the reading in dB, or 0.1 dB, whichever is greater. This figure includes calibration error plus frequency error.

*Power handling capacity, watts, avg continuous duty.

[1]Circular flange adapters available: HP 11515A (UG-425/U).

[2]Circular flange adapters available: HP 11516A (UG-381/U).

[3]Circular flanges.

1. DESCRIPTION.

2. Model 382A Variable Precision Attenuators are designed for use in waveguide systems operating in the 3.95 - 40.0 GHz range. Each model of the 382A series provides calibrated attenuation of from zero to 50 dB at any frequency within the rated waveguide band.

3. Attenuation is read directly on the dial. Residual (attenuation at zero setting) is less than 1 dB over the waveguide range. Backlash is less than 0.3 dB at 50 dB. The SWR is low and variation of phase with setting is practically negligible.

4. INITIAL INSPECTION.

5. MECHANICAL CHECK. If damage to the shipping carton is evident, ask that the carrier's agent be present when the instrument is unpacked. Inspect the instrument for mechanical damage such as scratches, dents or broken knobs. Also check the cushioning material for signs of severe stress (compacting).

6. PERFORMANCE CHECK. The electrical performance of the 382A should be verified as soon as possible after receipt. A performance check suitable for incoming inspection is given in Paragraphs 31 through 51.

7. CLAIM FOR DAMAGE. If the 382A is mechanically damaged or fails to meet specifications on receipt, notify the carrier and the nearest Hewlett-Packard office immediately. (A list of field offices is at the back of this note.) Retain the shipping carton and the padding material for the carrier's inspection. The field office will arrange for the repair or replacement of your instrument without waiting for the claim against the carrier to be settled.

8. HANDLING.

9. CARE OF FLANGES.

10. Take care to prevent damage to the face of the coupling flanges. Any scoring of the mating surfaces tends to increase the separation of the flange faces and will cause increased leakage and loss, particularly where a current maximum and voltage minimum occur at the joint. When storing the 382A, be sure to replace the flange covers to preclude damage to the joints.

11. AVOID VERTICAL SHOCK.

12. When shipping or handling a Model G, H, or J382A in a manner which will subject it to shocks in a vertical plane, always set the attenuation dial to zero. With the dial at zero, danger is minimized that vertical shocks will cause the attenuator flag to move downward, releasing tension on the drive cable. When the tension is released, the drive cable can jump out of the grooved portion of the drum, in which case the flag will be positioned approximately half-way between the scales. If this should occur, the trouble is easily remedied: remove the cover and slip the cable back into its groove on the drum. The accuracy of the attenuator will not be affected in any way.

13. OPERATION.

14. ALIGN FLANGES.

15. The height of the Model 382A should be adjusted carefully so that precise alignment will be obtained at the coupling flanges to prevent undue strain on one flange while the other is unsupported. A screw at each corner of the base will enable height and leveling adjustments to be made. When the instrument is supported at both ends, as in permanent installations, the feet or base may be removed altogether, if desired (M, K, or R bands).

16. DO NOT FORCE DIAL STOPS.

17. When setting attenuation do not force the dial against the mechanical stops at the ends of the attenuation range. Forcing the dial can change the calibration.

18. SETTING ATTENUATION.

19. Attenuation is set by the knob and read directly on the dial. A white background strip moves behind the dial window to select the range to read (not on M, K, or R band). Read only the range with the white background. The MAX setting gives the maximum attenuation - at least 70 dB at all frequencies.

20. PRINCIPLES OF OPERATION.

21. Basically the attenuator consists of three sections of waveguide in tandem. In each section a resistive film is placed across the guide as shown in Figure 1. The middle section is a short length of round guide which is free to rotate radially with respect to the two fixed end sections. The end sections are rectangular-to-round waveguide transitions in which the resistive films are normal to the E field of the applied wave. The construction is symmetrical and the device is bidirectional

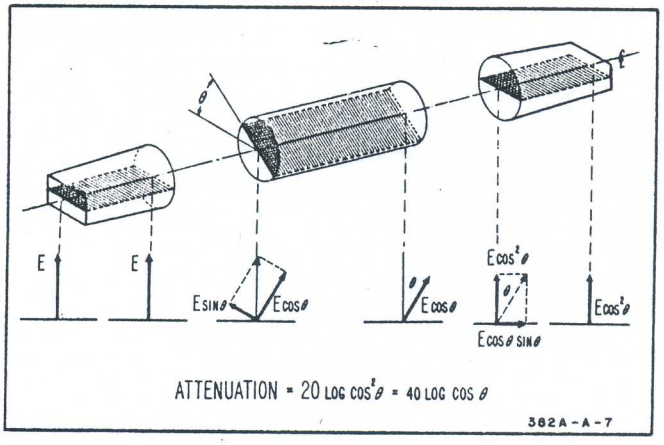


Figure 1. Attenuation Principle

22. When all films are aligned, the E field of the applied field is normal to all films. When this occurs, no current flows in the films and no attenuation occurs. If the center film is rotated to some angle θ, the E field can be considered to be split into two orthogonal components: E sin θ in the plane of the film, and E cos θ at right angles to it. The E sin θ component is absorbed by the film, while the E cos θ component oriented at an angle θ with respect to the original wave, is passed unattenuated to the third section. When it encounters the third film, the E cos θ component is absorbed, and the E $\cos^2 \theta$ component emerges at the same orientation as the original wave.

23. The attenuation is thus ideally proportional only to the angle to which the center film is rotated and is completely independent of frequency. In dB terms the attenuation is equal to 40 log cos θ.

24. Maximum attenuation of the attenuator exceeds the 50 dB calibrated range by at least 20 dB but the characteristics in this range are not controlled. Theoretically, the attenuator is capable of very high attenuation. In practice this property is modified by the fact that the resistive film in the middle section cannot completely absorb the E sin θ component. Hence, a small leakage component is passed to the output. For high attenuation above 50 dB, the leakage component begins to approach the magnitude of the desired output of the attenuator. Ultimate attenuation of this device thus becomes limited by the attenuation of the center rotating film which is 70 dB or more.

25. The accuracy of the attenuator does not depend on the stability of the resistive films: as long as their attenuation is high and remains high, performance is not affected.

26. SOURCES OF ERROR.

27. One of the principle sources of error in the Model 382A is internal reflections and finite attenuation in the center film. Reflections are minimized by tapers on the films and careful design of the transitions and choke joints. The center film attenuation is made as great as possible, consistent with low reflections and reasonable length and is at least 70 dB. Since this attenuation does vary with frequency it is not possible to calibrate the instrument all the way to 90° rotation (maximum attenuation). A margin of about 20 dB is necessary to maintain accuracy, so calibration is carried to 50 dB.

28. Another principle source of error is higher-order mode propagation in the circular waveguide. The other modes (TM_{01} and TE_{21}) can exist in addition to the wanted TE_{11} mode. The TM_{01} mode is equally attenuated at all angles of the center section but cannot be attenuated completely. The TE_{21} mode should not be excited if the choke sections and transitions are perfectly aligned. In practice, however, the choke sections are not perfectly matched at all frequencies. Therefore, above cutoff of the TE_{21} mode, in the top one-quarter of the frequency band, some sharp resonances could occur unless these modes are suppressed. Polyiron grooves are added in the center section to overcome these sources of error.

Table 2. Test Equipment Required

The following are test instruments and accessories required for performance checking. Test instruments other than those listed may be used provided their performance equals or exceeds the Critical Specifications.

Instrument Type	Critical Specifications	Recommended HP Model
Sweep Oscillator*	Frequency: band of 382A Internal AM: 1000 Hz square wave Leveling: ±0.5 dB from external signal Sweep Output: for recorder	8690 series
Directional Couplers (3) (1 with calibration curve)	Coupling: 10 dB ±0.4 dB Directivity: >40 dB	752C
Calibrated Variable Attenuator	Attenuation: 0 to 50 dB Insertion Loss: <1 dB SWR: <1.15 over entire range	382A
Crystal Detectors (3)	Frequency: band of 382A Response: flat, no tuning	424A
SWR Meter	Frequency: 1000 Hz Input Impedance: 200K ohm Output: compatible with Recorder	415 B/E
WG-Coaxial Adapter	SWR: <1.25	281A
X-Y Recorder with 1000 Hz Filter	Compatible with SWR Meter and Sweep Oscillator used	Moseley 135C
Waveguide Short	Frequency: band of 382A	920A, B, X923A in X-band
Moveable Load	Frequency: band of 382A SWR: <1.01	914A/B

*May need additional TWT Amplifier depending upon band, output, sensitivity of detector, etc. A TWT Amplifier should not be used unless necessary due to increased noise level.

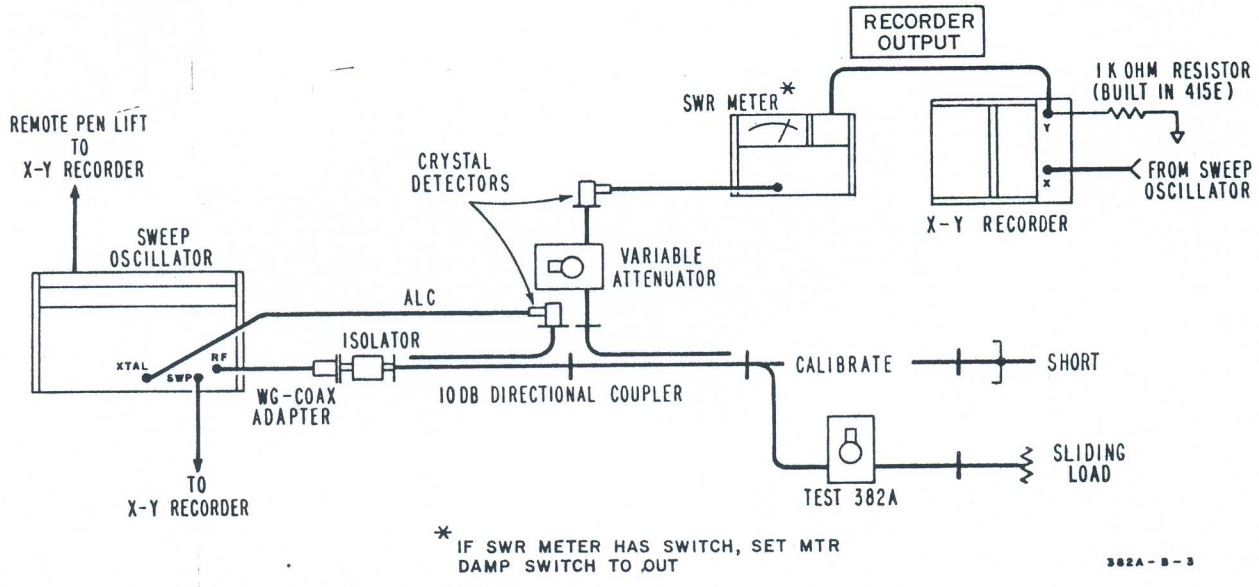


Figure 2. RF Pre-Insertion - X-Y Recorder Setup for ρ Tests