Agilent Technologies
Innovating the HP Way

OPERATING AND SERVICE MANUAL
SPECIAL SUPPLEMENT

E4418B OPTION K15
DUAL 50MHz 1mW POWER REFERENCE ASSEMBLY

MODEL NUMBER: **E4418B Option K15**
REVISION: **A, February 2000**

CONTENTS

E4418B Option K15

Description

The E4418B Option K15 is a dual 50MHz power reference oscillator for verifying the accuracy of power meters and their mounts at a 1.00mW level.

Specifications

POWER REFERENCE:	Power output 1.00mW. factory set to ± 0.7 % traceable to the National Institute of Standards and Technology.
ACCURACY:	± 1.2% worst case (± 0.9% rms) for one year (0°C to 55°C).
FREQUENCY:	50MHz Nominal
IMPEDANCE:	50Ω Nominal

Operation

POWER	100 to 240V AC 50VA Max. 50 to 440Hz
FUSE	240V F3 15AH

Connect the instrument to the proper mains, and turn the instrument on..The power reference oscillators do not have to be operating continuously. Allow a warm up time of five minutes before using the power reference output. The only operator controls on this instrument are the POWER REF ON OFF switches and the MAINS ON/OFF switch The function of the switches is self-explanatory.

Field repair of HP E4418B Option K15 should be limited to the primary circuits and power supply assemblies. Field repair of either oscillator should not be attempted because the precision equipment required is not normally available in the field.

Power Reference Level Test

Specification

The E4418 Opt K15 1mW 50 MHz oscillators are factory set to 1mW ±0.7 % traceable to the National Institute of Standards and Technology:

Accuracy: ±1.2% worst case (±0.9% rms) for one year (0°C to 55°C).

Description

The power reference oscillator output is factory adjusted to 1mW ± 0.7 %. To achieve this accuracy, Agilent Technology employs a special measurement system accurate to 0.5 % (traceable to the National Institute of Standards and Technology) and allows for a transfer error of ±0.2 % in . If an equivalent measurement system is employed for verification, the power reference oscillator output can be verified to 1mW ±1.9 % (± 1.2% accuracy + ±0.5 % verification system error + ±0.2 % transfer error = 1.9 % maximum error). The power reference oscillator can be set to ± 0.7 % using the same equipment and following the adjustment procedure in this manual. To ensure maximum accuracy in verifying the power reference oscillator output, the following procedure provides step-by-step instructions for using specified Hewlett Packard test instruments of known capability. If equivalent test instruments are used, signal acquisition criteria may vary and reference should be made to the manufacturer's guidelines for operating the instruments.

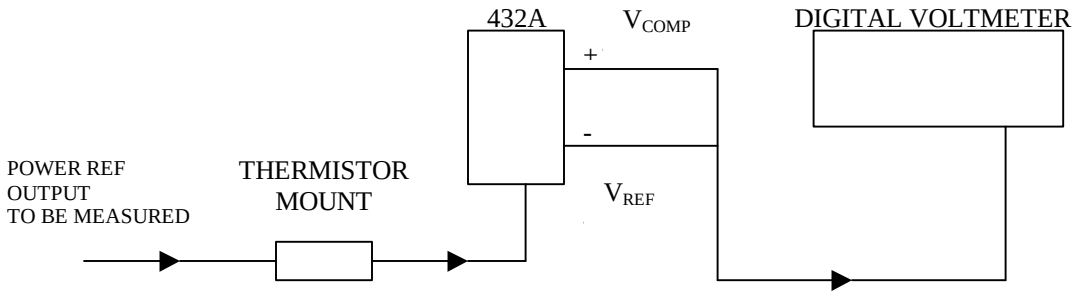

Figure 1-1. Power Reference Level Test Setup

Equipment

Power Meter . . . . . HP 432A

Thermistor Mount . . . . . HP 478A-H75
(This is a modified HP 478A having VSWR < 1.05 at 50 MHz).

Digital Voltmeter (DVM) . . . . . HP 345

Procedure

1. Set up the DVM to measure resistance and connect the DVM between the V_{RF} connector on the rear panel of the HP 432A, and pin 1 on the thermistor mount end of the HP 432A interconnect cable.

2. Round off the DVM indication to two decimal places and record this value as the internal bridge resistance (R) of the HP 432A (approx. 200Ω).

3. Connect the HP 432A to the Power Ref Output as shown in Figure 1-1.

4. Wait thirty minutes for the HP 432A thermistor mount to stabilize before proceeding to the next step.

5. Set the HP 432A **RANGE** switch to **COARSE ZERO** and adjust the front panel **COARSE ZERO** control to obtain a zero meter indication.

6. Fine zero the HP 432A on the most sensitive range, then set the HP 432A **RANGE** switch to 1mW.

NOTE Ensure that DVM input leads are isolated from chassis ground when performing the next step.

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7. Set up the DVM to measure microvolts and connect the positive and negative input leads respectively, to the V_{COMP} and V_{RF} connectors on the rear panel of the HP 432A.

8. Observe the indication on the DVM. If less than 400 microvolts, proceed to the next step. If 400 microvolts or greater, press and hold the HP 432A **FINE ZERO** switch and adjust the **COARSE ZERO** control so that the DVM indicates 200 microvolts or less. Then release the **FINE ZERO** switch and proceed to the next step.

9. Round off the DVM indication to the nearest microvolt and record this value as V_0.

10. Apply the power to the E4418 Option K15 and record the indication observed on the DVM as V_1.

11. Disconnect the DVM negative input lead from the V_{RF} connector on the HP 432A and reconnect it to the HP 432A chassis ground. Record the new indication observed on the DVM as V_{COMP}.

12. Calculate the power reference oscillator output level (P_{RF}) from the following formula:

$$P_{RF} = \frac{2\ V_{COMP}\ (V_1 - V_0) + (V_0^2 - V_1^2)}{4\ R\ (\text{CALIBRATION FACTOR})}$$

Abbreviations:

P_{RF}	=	Power references oscillator output level
V_{COMP}	=	Previously recorded value
V_1	=	Previously recorded value
V_0	=	Previously recorded value
R	=	Previously recorded value
Calibration Factor	=	Value for thermistor mount at 50 MHz (traceable to the National Institute of Standards and Technology).

13. Verify that the P_{RF} is within the following limits:

Min.	Actual	Max.
0.988mW	-	1.012mW

Power Reference Oscillator Frequency Adjustment

Note Adjustment of the E4418 Opt K15 Power Reference Oscillator frequency may also affect the output level of the oscillator. Therefore, after the frequency is adjusted to 50.0 ±0.5MHz, the output level should be checked as described in pages 1-1 to 1-4. A procedure for adjusting the output to the specified level is provided in the next paragraph.

Reference

Figure 1-2

Description

The 'FREQ ADJ' is adjusted to set the power reference oscillator output frequency to 50.0±0.5MHz.

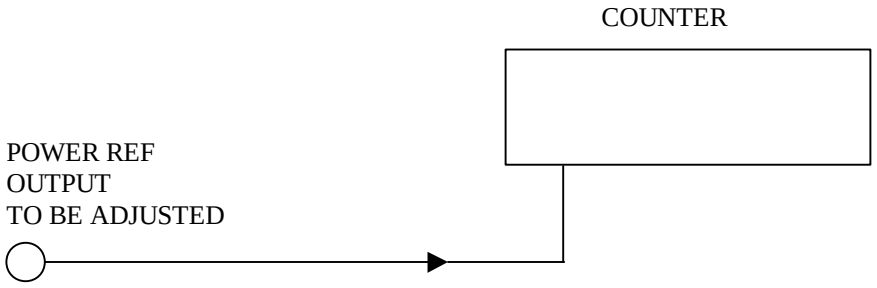

Figure 1-2.

Equipment

Counter . . . . . HP 5315A

Procedure

1. With the E4418 Opt. K15 powered up set up the counter to measure frequency and connect the equipment as shown in figure 1-2.

2. Observe the indication on the counter. If it is 50.0±0.5MHz, no adjustment of the power reference oscillator frequency is necessary. If it is not within these limits, adjust the power reference oscillator frequency as described in steps 3.

3. Adjust the 'FREQ ADJ' on the E4418 Opt. K15 to give a frequency reading on the counter of 50.0 ± 0.5MHz.

Power Reference Oscillator Level Adjustment

Reference

Figure 1-3

Description

The E4418 Opt. K15 power reference oscillator output is factory adjusted to 1mW ± 0.7 %. To achieve this accuracy, Agilent Technology employs a special measurement system accurate to 0.5 % (traceable to the National Institute of Standards and Technology) and allows for a transfer error of ± 0.2 % in making the adjustment. To ensure maximum accuracy in verifying the power reference oscillator output, the following procedure provides step-by-step instructions for using specified Agilent Technology test instruments of known capability. If equivalent test instruments are used, signal acquisition criteria may vary and reference should be made to the manufacturer's guidelines for operating the equipment.

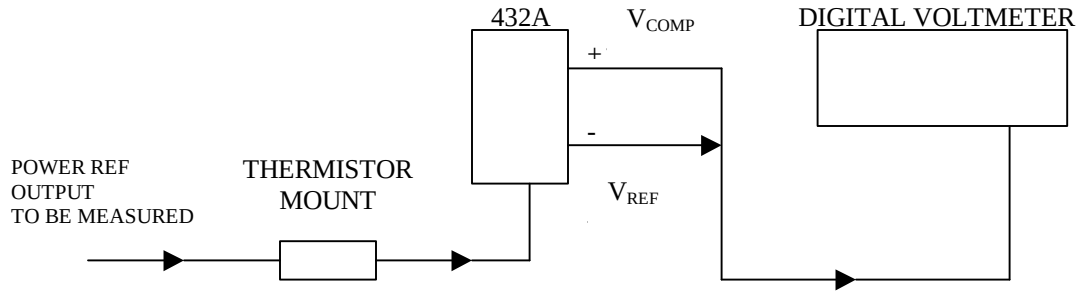

Figure 1-3. Power Reference Oscillator Level Adjustment Set-up

Equipment

Power Meter . . . . . HP 432A

Thermistor Mount . . . . . HP 478A-H75
(This is a modified HP 478A having VSWR < 1.05 at 50 MHz).

Digital Voltmeter (DVM) . . . . . HP 3456A

Procedure

1. Set up the DVM to measure resistance and connect the DVM between the V_{RF} connector on the rear panel of the HP 432A, and pin 1 on the thermistor mount end of the HP 432A interconnect cable.
2. Round off the DVM indication to two decimal places and record this value as the internal bridge resistance (R) of the HP 432A (approx. 200Ω).
3. Connect the HP 432A to the Power Ref Output as shown in Figure 1-3.
4. Wait thirty minutes for the HP 432A thermistor mount to stabilize before proceeding to the next step.
5. Set the HP 432A **RANGE** switch to **COARSE ZERO** and adjust the front panel **COARSE ZERO** control to obtain a zero meter indication.
6. Fine zero the HP 432A on the most sensitive range, then set the HP 432A **RANGE** switch to 1mW.

NOTE	Ensure that DVM input leads are isolated from chassis ground when performing the next step.

7. Set up the DVM to measure microvolts and connect the positive and negative input leads respectively, to the V_{COMP} and V_{RF} connectors on the rear panel of the HP 432A.
8. Observe the indication on the DVM. If less than 400microvolts, proceed to the next step. If 400microvolts or greater, press and hold the HP 432A **FINE ZERO** switch and adjust the **COARSE ZERO** control so that the DVM indicates 200microvolts or less. Then release the **FINE ZERO** switch and proceed to the next step.
9. Round off the DVM indication to the nearest microvolt and record this value as V_0.
10. Disconnect the DVM negative input lead from the V_{RF} connector on the HP 432A and reconnect it to chassis ground.
11. Apply the dc power supply to the E4418 Option K15 and record the indication observed on the DVM as V_{COMP}.
12. Disconnect the DVM negative input lead from chassis ground and reconnect it to the V_{RF} connector on the rear panel of the HP 432A. The DVM is not set up to measure V_1 that represents the power reference oscillator output level.

13. Calculate the value of V_1 equal to 1milliwatt from the following equation:

$$V_1 - V_0 = V_{COMP} - \sqrt{[(V_{COMP})^2 - (10^{-3})(4R)(\text{EFFECTIVE EFFICIENCY})]}$$

Abbreviations:

V_0	=	Previously recorded value
V_{COMP}	=	Previously recorded value
10^{-3}	=	1 mW
R	=	Previously recorded value
EFFECTIVE EFFICIENCY	=	Value for thermistor mount at 50MHz (traceable to the National Institute of Standards and technology)

14. Adjust the E4418 Opt. K15 '**LEVEL ADJUST**' so that the DVM indicates the calculated value of V_1 (See Figure 4).

Typical Calculations

1. Accuracy:

DVM Measurements	(V_{COMP})	±0.018 %
(HP 3456A - 90days, 23°C ±5°C)	(V1 - V0)	±0.023 %
	(R)	±0.03 %
Math Assumptions:		±0.01 %
EFFECTIVE EFFICIENCY CAL (NIST)		±0.5 %
MISMATCH UNCERTAINTY:		
(Source & Mount SWR ≤1.05)		±0.1 %
		≤±0.7 %

2. Math Assumptions:

$$P_{RF} = \frac{2\,V_{COMP}\,(V_1 - V_0) + (V_0^2 - V_1^2)}{4\,R\,(\text{EFFECTIVE EFFICIENCY})}$$

Assume: $V_0^2 - V_1^2 = (V_1 - V_0)^2$
$-(V_1 - V_0)^2 = -V_1^2 + 2 * V_1 - V_0^2$

Want: $V_0^2 - V_1^2$

$\therefore$ error $= (V_1^2 - 2\,V_1\,V_0 - V_0^2) - (V_0^2 - V_1^2) = -2\,V_0^2 - V_1\,V_0 = 2\,V_0\,(V_1 - V_0)$

if $2\,V_0\,(V_1 - V_0) << 2\,V_{COMP}\,(V_1 - V_0)$ i.e. $V_0 << V_{COMP}$, error is negligible.

$V_{COMP} \sim 4$ volts. If $V_0 < 400\mu V$, error is < 0.01 %.

(typically V_0 can be set to $< 50\mu V$).

3. Derivation of Formula for $V_1 - V_0$

$$P_{RF} = \frac{2\,V_{COMP}\,(V_1 - V_0) + (V_0^2 - V_1^2)}{4\,R\,(\text{EFFECTIVE EFFICIENCY})}$$

Desired $P_{RF} = 1mW = 10^{-3}$

$$\therefore\ 10^{-3} = \frac{2\,V_{COMP}\,(V_1 - V_0) + (V_0^2 - V_1^2)}{4\,R\,(\text{EFFECTIVE EFFICIENCY})}$$

Let $4\,R\,(\text{EFFECTIVE EFFICIENCY})\ 10^{-3} = K$

Substitute $-(V_1 - V_0)^2$ for $V_0^2 - V_1^2$ (see Math Assumptions under Accuracy)

Then $0 = (V_1 - V_0)^2 - 2\,V_{COMP}\,(V_1 - V_0) + K$

Or $V_1 - V_0 = V_{COMP} - \sqrt{[(V_{COMP})^2 - K]}$

PCB PART NUMBERS

Material List		E4418 60020 Assemblies	E4418 60019 Assemblies	Total
HP Part No.	Description	Ref Des.	Ref Des	QTY
0160-6736	CAP 0.01uF 50 V	C112	C85	2
0160-7751	CAP 0.01uF 50 V	C86	C86	2
0160-7751	CAP 0.01uF 50 V	C87	C87	2
0160-7751	CAP 0.01uF 50 V	C88	C88	2
0160-7835	CAP 100pF 50 V	C89	C89	2
0180-4274	CAP 4.7uF 50 V	C90	C90	2
0160-7771	CAP 8.2pF 50 V	C91	C91	2
0160-7708	CAP 1000pF 50 V	C92	C92	2
0160-7855	CAP 33pF 50 V	C93	C93	2
0160-7751	CAP 0.01uF 50 V	C94	C94	2
0160-7088	CAP 36pF 300 V	C95	C95	2
0160-7087	CAP 200pF 300 V	C96	C96	2
0160-7751	CAP 0.01uF 50 V	C97	C97	2
1900-0245	DIO- SCHOTTKY SM	CR2	CR6	2
5183-7401	LTB 0122-0299	CR3	CR7	2
1250-1425	CONN-RF SMC	J13	J13	2
00436-80002	COIL 3 1/2 TURNS	L10	L10	2
9140-1121	IDCTR-FXD 100uH	L11	L5	2
9140-1109	IDCTR-FXD 4.7uH	L6	L6	2
9140-1109	IDCTR-FXD 4.7uH	L7	L7	2
9140-1109	IDCTR-FXD 4.7uH	L8	L8	2
00436-80001	VARIABLE COIL	L9	L9	2
1854-1037	XSTR NPN SI	Q2	Q10	2
1854-0247	XSTR NPN SI	Q3	Q11	2
1853-0567	XSTR PNP SI	Q4	Q8	2
1854-1037	XSTR NPN SI	Q5	Q9	2
0699-3954	RES 1.96K 1%	R100	R100	2
0699-3921	RES 75 1% .063W	R105	R101	2
0699-3937	RES 348 1% .063W	R106	R102	2
0699-2829	RES 50 .1% .125W	R107	R103	2
0699-1388	RES 7.5K 1%	R131	R86	2
0699-1404	RES 34.8K 1%	R132	R87	2
0699-3970	RES 10K 1% .063W	R88	R88	2
0699-3970	RES 10K 1% .063W	R89	R89	2
Material List		E4418 60020	E4418 60019	Total

Assemblies

2100-3091	RES-TRMR 2K 10%	R90	R90	2
0699-4596	RES 6.81K 1%	R91	R91	2
0699-3945	RES 825 1% .063W	R92	R92	2
0699-3967	RES 7.5K 1%	R93	R93	2
0699-3993	RES 100K 1%	R94	R94	2
0699-3368	RES 56.2K 1%	R95	R95	2
0699-3993	RES 100K 1%	R96	R96	2
0699-3947	RES 1K 1% .063W	R97	R97	2
0699-3947	RES 1K 1% .063W	R98	R98	2
0699-3970	RES 10K 1% .063W	R99	R99	2
1826-2218	IC 412	U24	U41	2
1902-0041	DIO-ZNR 5.11V 5%	VR1	VR1	2
1902-0680	DIO-ZNR 1N827	VR2	VR2	2
1200-0173	INSUL-XSTR DAP-G	MP4	MP4	2
E4418-00013	CALIBRATION SCRN	MP3	MP3	2
E4418-00017	LOWER CAL SCREEN	MP8	MP8	2
2950-0078	NUT-HEX-DBL-CHAM	MP5	MP5	2
2190-0124	WSHR-LK INTL T	MP6	MP6	2
2190-0124	WSHR-LK INTL T	MP7	MP7	2
9140-1354	IDCTR 47uH		L2 L3 L4	3
0180-4538	Cap 100uF 10V		C75	1
0180-4287	Cap 10uF 10V		C76 C77	2
0180-3472	Cap 1000uF		C72	1
0160-5945	Cap 0.01uF		C71	1
0811-3858	RES 21.5 Ohms		R191	1
1252-0238	Connector		P5	1
1251-7906	Connector		P6	1
1252-7557	Connector		J2	1
0403-0630	Ext.PC BD Brn			2
0403-0026	Glide Nylon			1
1251-6427	Fan Connector		J9	1
1251-6427	Connectors		OS 1 2 3	3
1251-3476	Contact-conn-F		1 2 3	3
1251-5388	Conn Post 0.1-Pin		1 2 3	3

Assembly Numbers

Item	Part Number	Qty	Description	
1	E4418-20001	1	Processor Unloaded	(E4418b-60019 Loaded)
2	E4418-20003	1	Measure bd. Unloaded	(E4418b-60020Loaded)
3	E4418-60015	1	Daughter board	
4	E4418-61020	1	Deck PSU and Fan	
5	E4418-61025	1	Chassis	
6	E4418-00009	1	Cover	
7	E4418-20001	1	Front Bezel	
8	E4418-20008	1	Rear Bezel	
9	E4401-45001	1	Handle	
10	34401-45011	1	Bumper	
11	E4418-61040	1	Semi Rigid (Long)	
12	E4418-61041	1	Semi Rigid (Short)	
13	E4418-20009	2	N Type connectors	
14	E4418-00039	1	Front panel	
15	3101-2359	1	Front Panel push switch	
16	RS330-985	2	Power Reference Switch	

END