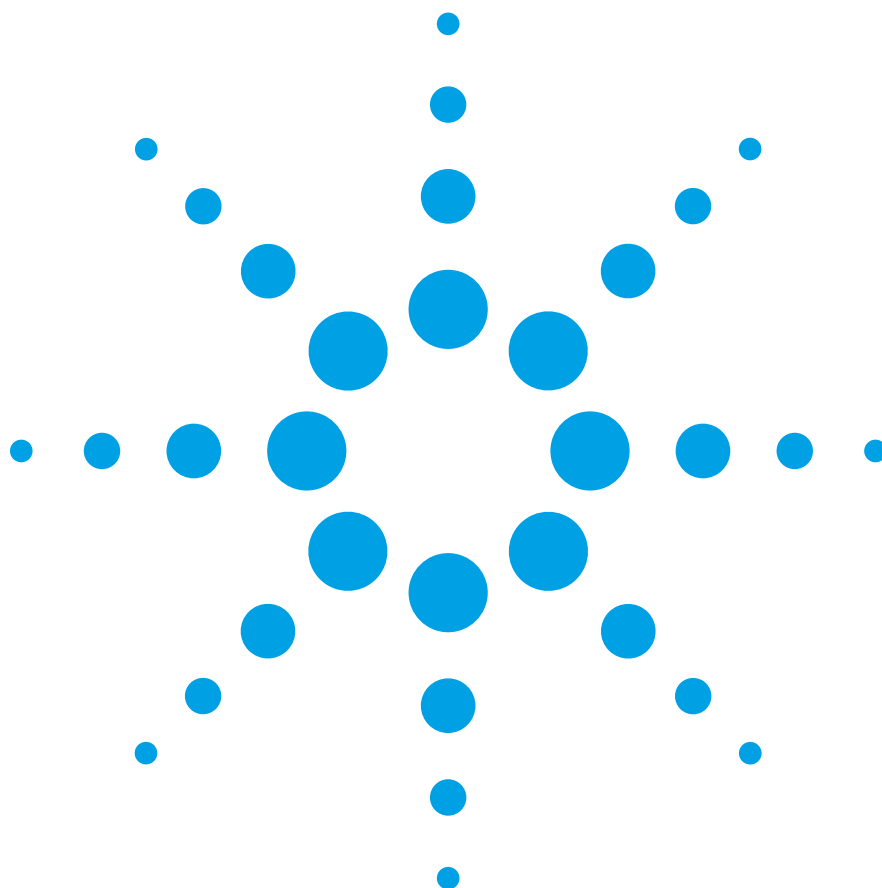


Remove all doubt

Your equipment restored to like new performance, returned on time.

A Comparison of Calibration Results from Three Calibration Service Providers

Application Note



Agilent Technologies

Introduction

When you need to calibrate your test and measurement equipment, you can choose from a variety of calibration service providers, including the instrument manufacturer. Calibration services provided by third-party vendors may look like an attractive alternative because they often offer lower prices. But do third-party calibration vendors do as good a job as the manufacturer would?

To answer that question, we asked an independent party to conduct a benchmark test to compare the quality of calibration service performed by the Agilent Service Center and two well-known, reputable, U.S. third-party calibration service providers (“Third-Party Calibration Vendor A” and “Third-Party Calibration Vendor B”) on three instruments: an Agilent 3458A high-performance multimeter, an Agilent E4440A PSA Series spectrum analyzer and an Agilent E8257D PSG signal generator. None of the calibration vendors, including the Agilent Service Center, were aware that their results were being tracked for a benchmark test. This application note describes the results of that benchmark test.

Calibration service comparison - summary of results

Instrument	Third-Party Vendor A	Third-Party Vendor B	Agilent Service Center
3458A high-performance multimeter	FALSE PASS Calibrated using incorrect parameters, failed to report out-of-tolerance readings	FALSE PASS Calibrated using incorrect parameters, failed to report out-of-tolerance readings	PROPER PASS Calibrated using correct parameters, properly passed
E4440A PSA spectrum analyzer	FALSE PASS Failed to perform IF input accuracy test. Failed to report out-of-tolerance readings and returned unadjusted to customer	INCOMPLETE CALIBRATION Failed to deliver measurement data. Performed less than one-third of the manufacturer-specified tests	PROPER FAIL, ADJUSTED Performed full suite of tests, correctly found instrument out of specification, performed necessary adjustments
E8257D PSG signal generator	DECLINED TO CALIBRATE	INCOMPLETE DATA, UNABLE TO COMPLETE ADJUSTMENTS Offered to send instrument to manufacturer for “repairs”	PROPER FAIL, ADJUSTED AND RECALIBRATED

Calibration Comparison 1: Agilent 3458A Digital Multimeter

Procedure

Three 3458A DMMs were configured with Option 002, which is a high-stability option that requires tighter calibration tolerances than normal. The instruments were clearly marked as including Option 002.

Results: Completeness of measurements

All three vendors did the full range of tests specified in the 3458A Calibration Manual.

Results: Accuracy of measurements

An excerpt from the measurement report from the Agilent Service Center is shown in Figure 1. It includes the critical 10-V measurement, which is fundamental to the overall calibration of a 3458A. The unit calibrated by the Agilent Service Center was calibrated using the correct tolerances required for a 3458A configured with Option 002, which at 10 V is ± 0.0000628 V. The unit correctly received a "PASSED" rating for all DC volt gain tests.

DC VOLT GAIN TEST						PASSED
RANGE (VOLT)	INPUT (VOLT)	EXPECTED (VOLT)	MEASURED (VOLT)	DIFFERENCE (VOLT)	TOLERANCE (VOLT)	
=====	=====	=====	=====	=====	=====	
.1	+ .1	+ .09999975	+ .10000005	+ .00000030	+/- .00000177	
.1	- .1	- .10000023	- .10000125	- .00000102	+/- .00000177	
1.0	+1.0	+ .99999946	+1.00000517	+ .00000571	+/- .00000711	
1.0	-1.0	- .99999949	-1.00000559	- .00000610	+/- .00000711	
10.0	+10.0	+9.9999966	+10.0000580	+ .0000614	+/- .0000628	
10.0	-10.0	-9.9999975	-10.0000575	- .0000600	+/- .0000628	
100.0	+100.0	+100.000092	+100.000667	+ .000575	+/- .000841	
100.0	-100.0	-100.000032	-100.000639	- .000607	+/- .000841	
1000.0	+1000.0	+999.999933	+1000.00689	+ .00756	+/- .02018	
1000.0	-1000.0	-999.99999	-1000.00637	- .00638	+/- .02018	

Figure 1. Portion of 3458A calibration measurement report from Agilent Technologies Service Center

The units calibrated by third parties were calibrated using incorrect parameters and improperly received a "PASSED" rating. Several calibration errors were made, leading to these erroneous results:

1. Neither third-party vendor correctly identified the units as being configured with Option 002. Both vendors incorrectly calibrated the units to "standard configuration" tolerances. For example, at 10 V both third parties incorrectly used the standard configuration tolerances of ± 0.0000892 V, a 43 percent difference from the correct value of ± 0.0000628 V.
2. The measurement report from Third-Party Vendor A clearly shows the two 10-V readings and another reading (1 V) to be out of tolerance for even a standard configuration, as recorded on the measurement report. Yet the vendor mysteriously gave the unit an "IN TOLERANCE" rating. An excerpt from the measurement report is shown in Figure 2.

DC VOLTAGE TESTS					
CAL? 59(°C)	TEMP?(°C)	Difference(°C)	Limit(°C)		
35.44	37.6	-2.16	5		
Input dcv	TI Range dcv	Transfer Std Reading dcv	UUT Reading dcv	Difference dcv	Limit dcv
short	100 m	N/A	-0.00017	N/A	0.00106
short	1	N/A	-0.0000001	N/A	0.00000106
short	10	N/A	0.000000	N/A	0.0000023
short	100	N/A	0.00000	N/A	0.000036
short	1000	N/A	0.0000	N/A	0.00010
100 m	100 m	100.00093	100.00133	-0.0004	0.00212
1	1	1.0000003	1.000010	-0.0000104	0.00000998
1	10	1.000001	1.000011	-0.000010	0.0000111
-1	10	-1.000000	-1.000011	0.000011	0.0000111
-10	10	-10.000006	-10.000113	0.000107	0.0000892
10	10	10.000005	10.000109	-0.000104	0.0000892
100	100	100.00015	100.00113	-0.00098	0.001114
1000	1000	1000.0008	1000.0084	-0.0076	0.02396

Figure 2. Portion of actual 3458A calibration report from Third-Party Vendor A. Note that three measurements are clearly outside the limits indicated on the report. Yet this instrument was given an "IN TOLERANCE" rating, and no adjustments were performed.

3. **Third-Party Vendor B recorded the tolerance for the 10 kOhm measurement as ±0.00142 kOhms, which is too high by a factor of 10!** If the vendor had used the right tolerance, it should have correctly given the measurement an "OUT OF TOLERANCE" rating and performed adjustments. The 10 kOhm measurement is also fundamental to proper calibration of a 3458A, and improper calibration of it can have far-reaching consequences on the overall measurement capability of the instrument.

Calibration comparison 1: Conclusions

Ensuring that the results of an instrument calibration are valid requires knowledge of the equipment and attention to detail. Failure in either of these areas can result in equipment that produces erroneous measurements for unsuspecting users. The example shows that these kinds of errors could be more common than expected. Two third-party calibration providers failed to recognize important configuration information on instruments received. Both also made errors in calibration reporting that resulted in the instruments passing calibration when they should not have. Only the Agilent Service Center performed a proper 3458A calibration.

Calibration Comparison 2: Agilent E4440A PSA Series Spectrum Analyzer

Procedure

Three Agilent E4440A PSA high-performance spectrum analyzers were configured with Option AYZ, which allows external mixing, so you can use the instrument for higher frequency applications. All three units were known to be out of calibration on IF input accuracy, an important test for Option AYZ. The units were sent to the same three vendors as the 3458As.

Results: Completeness of measurements

The unit from Third-Party B was returned with a certificate only, not with the requested measurement data. **When asked for the data, the vendor said it was not available and the instrument had to be returned for calibration in order to obtain the information requested. It is clear from this that Third-Party B does not keep records on its calibration measurements.**

Figure 3 shows the tests performed by each calibration vendor.

Functions tested	Number of measurements		
	Agilent	Vendor A	Vendor B
Frequency reference accuracy	1	1	1
Power bandwidth accuracy	13	13	
Resolution bandwidth switching uncertainty	15	15	19
Residual responses	23	1	3
Displayed average noise level	77	78	100
Frequency readout accuracy	7	7	14
Count accuracy	1	1	1
Spurious responses	24	24	23
Frequency response above 3 GHz	118	118	
LO output amplitude accuracy	21		
Gain compression	3	3	
Third order intermodulation distortion	6	6	9
Second harmonic distortion	4	4	4
IF amplitude ripple	4	4	
IF phase ripple	1	1	
IF input accuracy	2		
Absolute amplitude accuracy	22	22	2
Display scale fidelity	8	8	6
Input attenuation switching uncertainty	13	13	10
Noise sidebands < 50 kHz offsets	4	4	4
Noise sidebands > 50 kHz offsets	4	4	4
Frequency response (Option B7J)	154	154	
Frequency response 300 kHz to 3 GHz	206	206	2
Preselector tune out accuracy	3		
Frequency response below 300 kHz	18	18	1
Total measurements	752	705	203

Figure 3. Comparison of tests performed in calibrating the E4440A PSA spectrum analyzer

The Agilent Service Center performed the full suite of recommended calibration tests. Third-Party A performed nearly as many tests as Agilent. **Third-Party B performed less than one-third of the manufacturer-specified tests.** This should raise questions about whether the instrument is indeed performing to specification after calibration. Only two frequency response measurements were made, versus the 206 specified by Agilent. The calibration performed by Third-Party B provides little confidence that the instrument is performing to specification in these important measurements.

Neither third party performed the IF input accuracy test. Failure to note this part of the instrument configuration and perform the required tests casts doubt over whether the instrument would perform accurately in extended-range applications.

The Agilent Service Center found the instrument to be out of specification on the IF input accuracy tests and performed the necessary adjustments to bring it back into calibration. Figure 4 shows the data before and after adjustment.

<u>Model:</u>	<u>Serial:</u>	<u>Test Name:</u>	<u>Test Date:</u>	
E4440A	MY45304648	IF Input Accuracy	02-Dec-2006	
IF INPUT ACCURACY External Mixing (Option AYZ) Reference Input = -20 dBm				
<u>Dither</u>	<u>IF Input Accuracy (dB)</u>	<u>+/- Measurement Uncertainty (dB)</u>	<u>Specification (dB)</u>	<u>Result PASS/FAIL</u>
On	-2.46	0.07	1.20	FAIL
Off	-4.48	0.07	1.20	FAIL

<u>Model:</u>	<u>Serial:</u>	<u>Test Name:</u>	<u>Test Date:</u>	
E4440A	MY45304648	IF Input Accuracy	02-Dec-2006	
IF INPUT ACCURACY External Mixing (Option AYZ) Reference Input = -20 dBm				
<u>Dither</u>	<u>IF Input Accuracy (dB)</u>	<u>+/- Measurement Uncertainty (dB)</u>	<u>Specification (dB)</u>	<u>Result PASS/FAIL</u>
On	0.10	0.07	1.20	PASS
Off	0.08	0.07	1.20	PASS

Figure 4. Agilent IF input accuracy test results, before and after adjustment

Results: Accuracy of measurements

As noted, Agilent was the only vendor to perform all the recommended tests. Excluding IF input accuracy, Agilent and Third-Party B found no other out-of-specification conditions for the parameters they measured. Third-Party A was a different story.

Figure 5 shows part of the measurement report where **the unit was clearly out of specification and received a "FAIL" result on four measurements. Yet on the certificate, the instrument was indicated to be "IN TOLERANCE"** (also shown in Figure 5) and returned unadjusted to the customer. This "false pass" is a serious error, causing the customer to think he has a unit performing to specifications, when in fact he does not. Measurements from the unit in this performance range cannot be trusted, and could result in faulty development work in R&D applications, or faulty product being shipped in production applications. Your losses could be significant.

Note that the Third-Party A also gave a "false pass" rating in the 3458A comparison.

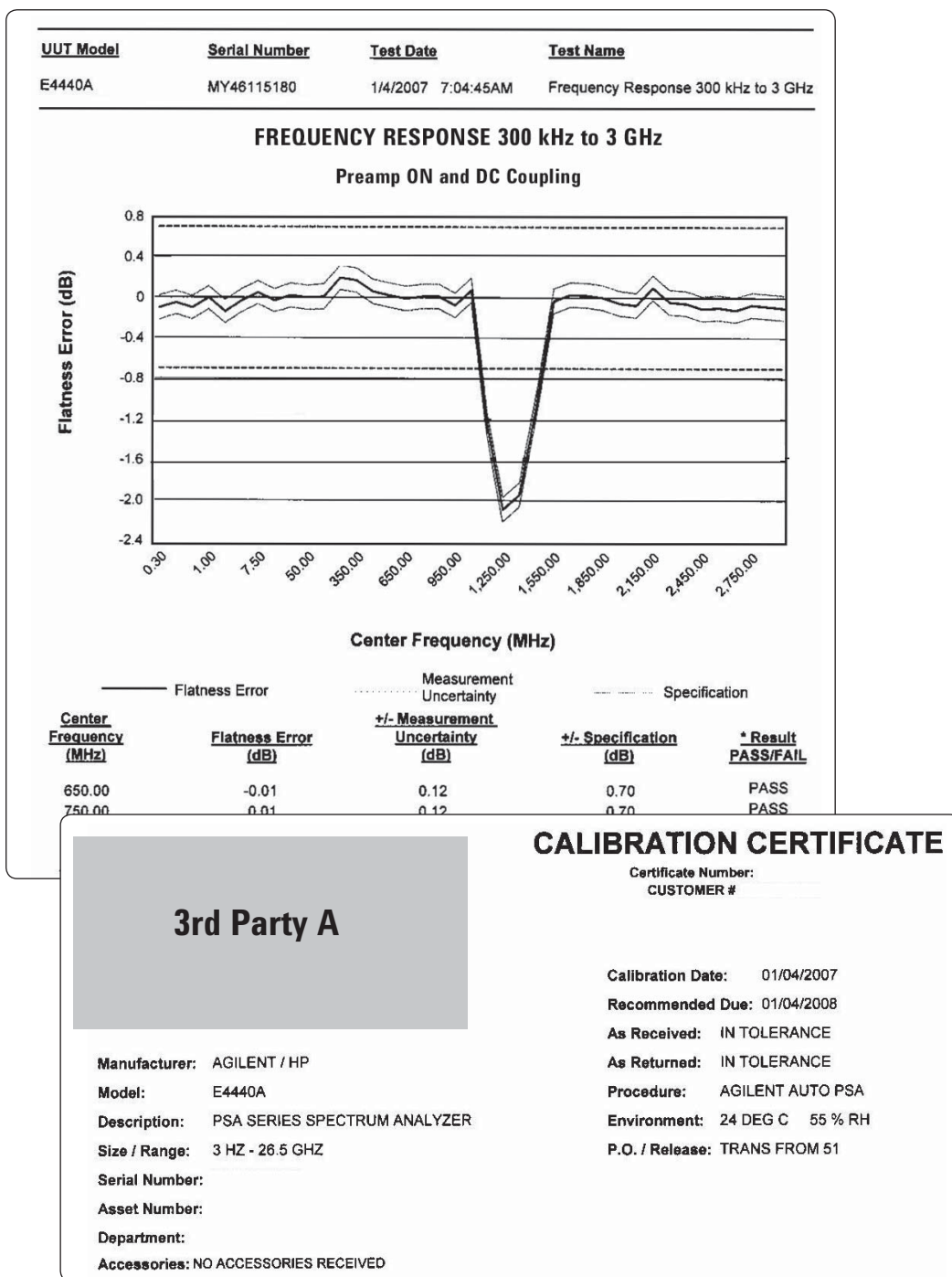


Figure 5. "False Pass" rating on E4440A spectrum analyzer by Third-Party A

Calibration comparison 2: Conclusions

The E4440A comparison demonstrates that the errors made by the third parties in the 3458A comparison were not isolated incidents. Serious errors were made in both calibrations. Only the Agilent Service Center demonstrated consistent, high-quality service. The E4440A is an expensive, high-performance instrument used in many critical design and production applications. When you purchase calibration services, you must decide whether you can afford the risk of a faulty calibration that could lead to bad design or production decisions due to inaccurate measurements.

Calibration Comparison 3: Agilent E8257D PSG Signal Generator

Procedure

The procedure was the same as that used in the two previous tests.

Results: Completeness of measurements

The Agilent Service Center performed the required 807 tests on the signal generator.

Third-Party A declined to calibrate the E8257D, saying “We cannot calibrate the instrument.”

It is not possible to determine the tests performed by Third-Party Vendor B. The measurement report received listed only those parameters that were out of adjustment (Figure 7, p. 10). These parameters bear little resemblance to the tests recommended by Agilent, the manufacturer.

Results: Accuracy of measurements

Figure 6 shows the summary page of the Agilent Service Center results by test area. Each test involves many measurements. If the unit fails just one measurement, it receives a “FAIL” rating on the test and fails the entire calibration. As you can see, this unit failed several test areas. The unit was adjusted and recalibrated. It passed calibration. The post-adjustment summary report is also shown in the figure.

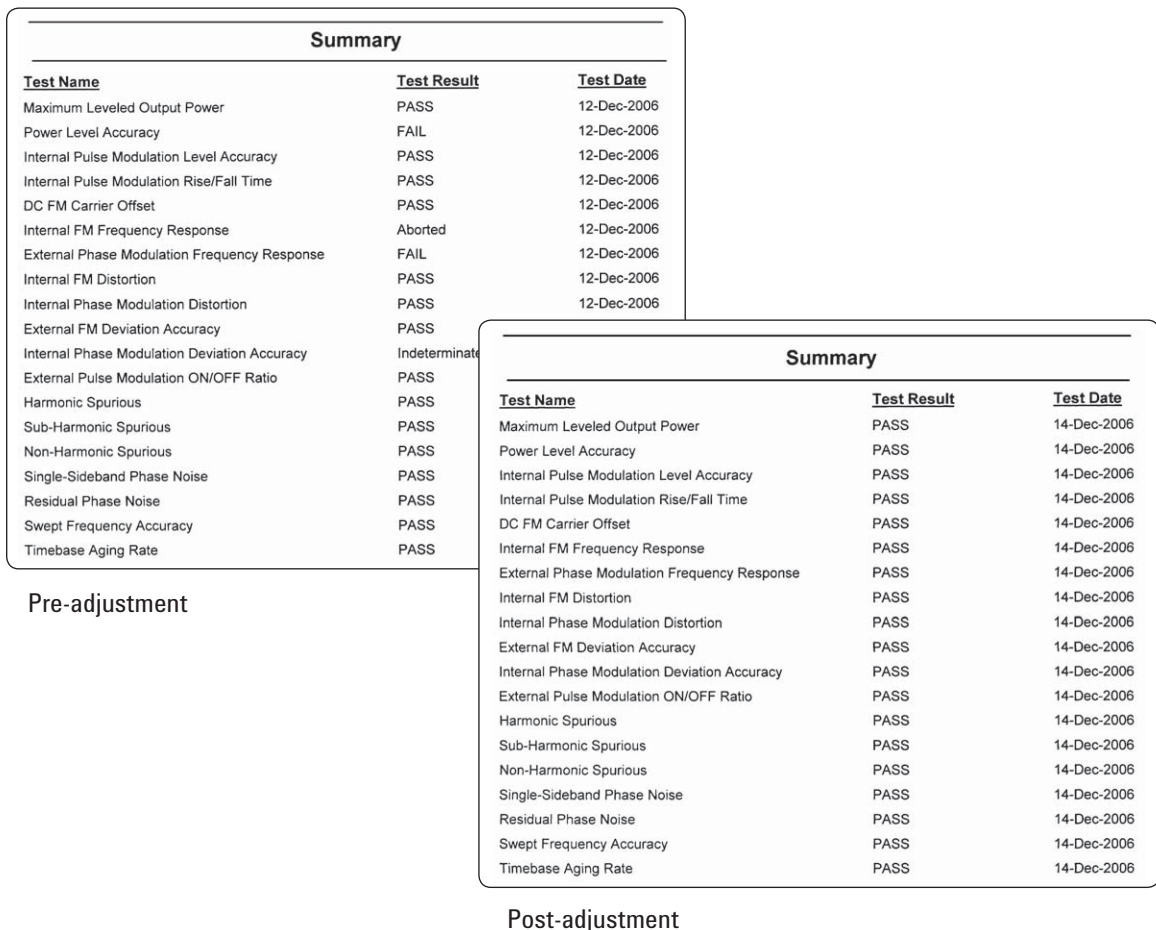


Figure 6. Pre- and post-adjustment data from E8257D calibration by the Agilent Service Center

Third-Party Vendor B also failed the unit they received for calibration, apparently correctly. As mentioned earlier, the measurement report received listed only the parameters that were out of adjustment (Figure 7). When the vendor was asked whether additional measurement data was available (i.e. the parameters that were in specification), its response was, "We are not able to get any additional data at this time. If you would like to resend it in, we can get a quote to send this to an outside vendor, and you would get additional data points. However, there would be an additional cost." This raised serious questions about the extent of testing done by Third-Party Vendor B, as was observed with the E4440A calibration.

The vendor communicated that it was not able to bring the unit back into specification, and that it would need to be sent to the manufacturer (Agilent) for "repair." The vendor quoted a minimum of \$1000 extra in charges and another 10 days turnaround time (it had already been 1 month since the equipment was shipped to the vendor).

Calibration Data:				
Parameter	Nominal	Measured Before	Measured After	Tolerance
FM MOD				
@249MHZ				
90KHZ DEV	90KHZ*	93.5		+/-3.2KHZ
DISTORTION	<1%*	1.08		<1.0%
@490MHZ				
45KHZ DEV	45KHZ*	47.2		+/-1.6KHZ
DISTORTION	<1%*	1.08		<1.0%
@990MHZ				
90KHZ DEV	90KHZ*	94.4		+/-3.2KHZ
DISTORTION	<1%*	1.09		<1.0%
@1.9GHZ				
100KHZ DEV	100KHZ*	105.1		+/-3.5KHZ
DISTORTION	<1%*	10.24		<1.0%
@3.19GHZ				
380KHZ DEV	380KHZ*	393.4		+/-13.3KHZ
DISTORTION	<1%*	1.16		<1.0%
@9.9GHZ				
380KHZ DEV	380KHZ*	399.8		+/-13.3KHZ
@19.9GHZ				
DISTORTION	<1%*	4.63		<1.0%
PHASE MOD				
@249MHZ				
8 RAD	8 RAD*	8.69		+/-0.41 RAD
@490MHZ				
4 RAD	4 RAD*	4.36		+/-0.21 RAD
DISTORTION	<1%*	1.21		<1.0%
@990MHZ				
8 RAD	8 RAD*	8.79		+/-0.41 RAD
DISTORTION	<1%*	1.52		<1.0%
@1.9GHZ				
4 RAD	4 RAD*	4.24		+/-0.21 RAD
8 RAD	8 RAD*	8.45		+/-0.41 RAD
14 RAD	14 RAD*	14.77		+/-0.71 RAD
19 RAD	19 RAD*	20.04		+/-0.96 RAD
@3.19GHZ				
38 RAD	38 RAD*	40.1		+/-1.91 RAD
@9.9GHZ				
78 RAD	78 RAD*	82.3		+/-3.90 RAD
@19.9GHZ				
150 RAD	150 RAD*	158.3		+/-7.50 RAD

Figure 7. Out-of-tolerance report on E9257D from Third-Party Vendor B

Calibration comparison 3: Conclusions

Not all third-party calibration providers, including national vendors with multiple sites like Third-Party Vendor A, have capability to calibrate RF/microwave equipment like the E8257D signal generator. Even if the vendor is capable, like Third-Party Vendor B, they may not be able to make adjustments. They may call these adjustments “repairs” and either return the instrument to you unadjusted or send it to the manufacturer as a second, separate service for which they charge extra. If your unit is out of specification and you send it to a third party, you run the risk of facing additional costs and delays. A calibration that was expected to take a few days can take weeks longer and cost much more than expected.

Final Conclusions

Calibration services provided by third-party vendors may look like an attractive alternative because they often offer lower prices. The tests documented in this application note, however, illustrate that these third-party vendors do not always provide the same completeness of calibration as the manufacturer. Much worse, these third-party vendors often make serious errors in calibration, giving instruments false “PASS” ratings. Incorrectly passed instruments can produce poor measurements, resulting in huge costs from faulty designs or defective product shipments. Can you really afford to take this type of risk?

For RF/microwave equipment, third parties often do not have the technical capability and rigorous procedures required for accurate calibrations. If they can calibrate the equipment, they may not be able to make adjustments. Therefore, you likely will experience significant additional costs, delays and disruptions in these situations. For many companies, downtime is very costly.

Agilent, the premier measurement company, has more than 50 years of experience in designing and maintaining top-quality measurement instruments. If you decide to work with a third-party to maintain your equipment, you must carefully assess the risk and hidden costs of calibration defects that are inherent in this choice.

Related Agilent Literature

Publication	Description	URL
Remove all doubt: Rely on Agilent Repair and Calibration Services to get your equipment restored to like-new performance and get it returned on time	Brochure	http://cp.literature.agilent.com/litweb/pdf/5989-5497EN.pdf
Minimizing Risk in Instrument Calibration	Application note	http://cp.literature.agilent.com/litweb/pdf/5989-5341EN.pdf

For more information, contact your Agilent representative or visit www.agilent.com/find/calibration



Agilent Email Updates

www.agilent.com/find/emailupdates
Get the latest information on the products and applications you select.



Agilent Direct

www.agilent.com/find/agilentdirect
Quickly choose and use your test equipment solutions with confidence.



www.agilent.com/find/open
Agilent Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Agilent offers open connectivity for a broad range of system-ready instruments, open industry software, PC-standard I/O and global support, which are combined to more easily integrate test system development.



www.lxistandard.org
LXI is the LAN-based successor to GPIB, providing faster, more efficient connectivity. Agilent is a founding member of the LXI consortium.

Remove all doubt

Our repair and calibration services will get your equipment back to you, performing like new, when promised. You will get full value out of your Agilent equipment throughout its lifetime. Your equipment will be serviced by Agilent-trained technicians using the latest factory calibration procedures, automated repair diagnostics and genuine parts. You will always have the utmost confidence in your measurements.

Agilent offers a wide range of additional expert test and measurement services for your equipment, including initial start-up assistance onsite education and training, as well as design, system integration, and project management.

For more information on repair and calibration services, go to:

www.agilent.com/find/removealldoubt

www.agilent.com

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Americas

Canada	(877) 894-4414
Latin America	305 269 7500
United States	(800) 829-4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	81 426 56 7832
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Thailand	1 800 226 008

Europe

Austria	0820 87 44 11
Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700* *0.125€ fixed network rates
Germany	01805 24 6333* *0.14€/minute
Ireland	1890 924 204
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
Switzerland (French)	41 (21) 8113811(Opt 2)
Switzerland (German)	0800 80 53 53 (Opt 1)
United Kingdom	44 (0) 118 9276201

Other European Countries:

www.agilent.com/find/contactus

Revised: May 7, 2007

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2007
Printed in USA, June 21, 2007
5989-6703EN



Agilent Technologies