



Agilent PN 8566B/8568B-1

Third Order Intermodulation Distortion Measurements: A Downloadable Procedure for Agilent 8566B and 8568B Spectrum Analyzers

Product Note

Introduction

Third order intermodulation distortion (IMD) measurements are complex and can be tedious when performed manually, even when sophisticated measuring instruments such as Agilent Technologies 8566B or 8568B Spectrum Analyzers are used. Performing such measurements automatically from a computer is far more efficient, since less operator time and effort is required. The downloadable capability of an 8566B or 8568B Spectrum Analyzer adds to this efficiency by making it possible to execute programs that are stored in the analyzer and get results, instead of data, from the analyzer.

This product note contains a complete program that measures the third order IMD products of two input signals in the range of 10 MHz to 500 MHz. This program can be downloaded into an 8566B or 8568B Spectrum Analyzer and executed from the analyzer front panel, or run from a computer.

Prerequisites

To fully understand the third order IMD program, some experience in analyzer programming is necessary. The *Introductory Operation Guide* (Agilent publication number 5952-9389) and the *Agilent 8566B or 8568B Operating and Programming Manual* (Agilent part numbers 08566-90040 and 08568-90041, respectively) are good references for developing an understanding of analyzer programming. An understanding of downloadable programming concepts is also required. *A Structured Approach to Downloadable Programming* (Agilent publication number 5952-9392) is a good source for such

information. Other references that may prove useful are *Spectrum Analysis... Distortion Measurements* (Agilent publication number 5952-9235), and *Quick Reference Guide for Agilent 8566B and Agilent 8568B Spectrum Analyzers* (Agilent publication number 5955-8970).

Equipment

A list of the equipment necessary to make third order IMD measurements follows:

- 1–Agilent 8566B or 8568B Spectrum Analyzer
 - 2–Signal sources, ranging in frequency from 10 MHz to 500 MHz (such as Agilent 8640B and 8656B Signal Generators)
 - 1–Signal combiner, such as an Agilent 8721A Directional Coupler (up to 100 MHz), 11667A power splitter, or Weinschel 1502 Combiner
 - 2–6 dB pads (recommended to improve isolation between signal sources)
 - 2–Low-pass filters (recommended if large IMD products are generated within the signal sources)
- Connecting cables, power cords, and adapters where necessary



Agilent Technologies

Innovating the HP Way

Test Setup

To simulate a test for third order IMD, connect the equipment as shown in Figure 1:

Why Measure Third Order Intermodulation Distortion?

Two-tone third order intermodulation is a common problem in narrow-band systems. When two (or more) signals are present in a system, strong harmonic components are often generated (See Figure 2). In cases where two signals are present, the two signals (f_1 and f_2) mix with each other's second harmonic ($2f_1$ and $2f_2$) and create distortion products evenly spaced about the fundamentals ($2f_1 - f_2$ and $2f_2 - f_1$). Components such as amplifiers, mixers, and filters can generate third order intermodulation distortion products.

These distortion products can degrade the performance of many communication systems, such as FM and AM transceivers and high frequency radio teletypes. For example, signals transmitted with excessive third order IMD can interfere with other transmissions. Receivers must also be distortion-free, especially in the preamplifier stages, to prevent crosstalk between adjacent channels.

Third Order Intermodulation Distortion Program

The program contained in this product note is designed to test for two-tone third order intermodulation distortion. The program begins by bringing the test tones on the analyzer display, setting the attenuator for optimum dynamic range, and measuring the amplitudes and frequencies of the input signals. It then locates the third order IMD products, measures them, and returns their amplitudes in dBc. It also reports the frequency separation and level of the test tones. If the third order IMD products are too low in amplitude to be measured, it reports this instead. The program can be executed from a computer or from the front panel of the analyzer.

The input signals must be in the range of 10 MHz to 500 MHz. They can be separated anywhere from 1 kHz to 10 kHz, and the difference in their amplitudes should be less than 2 dB. The program takes approximately 22 seconds to execute when measuring test tones that are 3 kHz to 10 kHz apart; it takes approximately 94 seconds to

execute when measuring test tones that are 1 kHz and 3 kHz apart. The program is accurate to within ± 0.4 dB for signal separations from 3 kHz to 10 kHz, with the spectrum analyzer operating in the corrected* mode. For signal separations from 1 kHz to 3 kHz, accuracy is ± 1.5 dB, with the analyzer operating in the corrected* mode.

When typing the program into the computer, follow all Agilent 8566B and 8568B programming syntax requirements. By typing the program as shown, these requirements will be met. Program comments (text appearing on a line after an exclamation point) may be omitted.

If downloadable procedures are already stored in the analyzer's RAM, it may be necessary to dispose of some or all of these procedures to provide the 4802 bytes of memory space required for the third order IMD program. To dispose of all procedures stored in RAM, type:

```
OUTPUT 718;"DISPOSE ALL;"
```

and press [EXECUTE].

* To access the corrected mode, press [SHIFT] [W], and [SHIFT] [X]. The analyzer must be operating in the 20 °C to 30 °C temperature range. The accuracy of the results is reduced when the analyzer is not operated in the corrected mode.

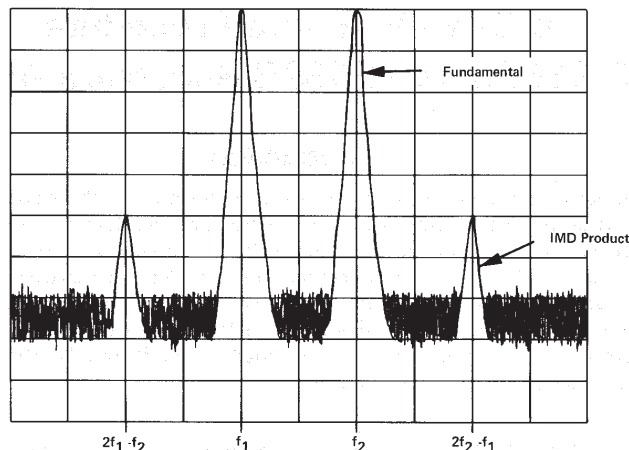


Figure 2. Two-Tone Third Order Intermodulation (Fundamentals and IMD Products)

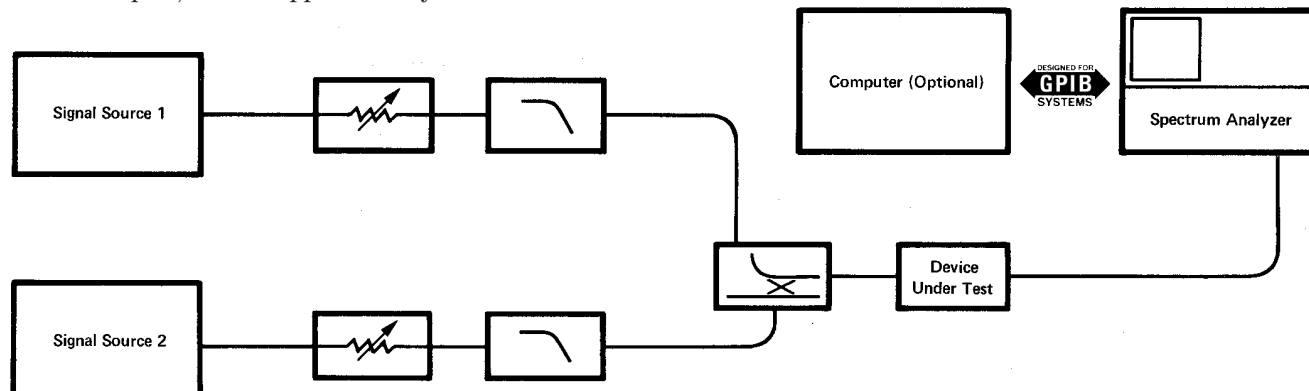


Figure 1. Test Setup for Third Order IMD Measurements

Program List

The following is a line-by-line listing of the program, followed by the program annotation.

```
10 ! Filename: T_HIRDIMOD Date: 25.12.84
20 ! Description of program: This is a downloadable program for the
30 ! 8566B and 8568B that measures the
40 ! third order intermodulation products of
50 ! two equal amplitude signals that are
60 ! separated in frequency from 1 kHz to
70 ! 10 kHz. The test tones must be within
80 ! the 10 MHz to 500 MHz frequency range.
90 ! The program sets the attenuator for opti-
100 ! mum dynamic range and tests that the test
110 ! tones are equal in amplitude (within 2 dB).
120 ! The program reports if no third order
130 ! products appear above the noise level.
140 ! Executable using: T_HIRDIMOD or <SHIFT> <2> <Hz>
150 ! Execution time: Separations from 3 kHz to 10 kHz; 22 sec.
160 ! Separations from 1 kHz to 3 kHz; 94 sec.
170 !
180 ! Required memory allocation: 4802 bytes
190 !
200 ! Program begins here. . .
210 !
220 ASSIGN @Sa TO 718
230 !
240 ! INITIALIZE VARIABLES AND TRACES
250 !
260 OUTPUT @Sa;"VARDEF O_PTRANGE,0;VARDEF T_ONE,0;VARDEF T_TWO,0;"
270 OUTPUT @Sa;"VARDEF T_ONEAMP,0;VARDEF T_TWOAMP,0;VARDEF H_EIGHT,0;"
280 OUTPUT @Sa;"VARDEF D_IFF,0;VARDEF N_OISE,0;"
290 OUTPUT @Sa;"VARDEF I_MRDBC,0;VARDEF I_MLDBC,0;"
300 OUTPUT @Sa;"VARDEF H_OLD,0;VARDEF L_EFT,0;"
310 OUTPUT @Sa;"TRDEF S_TORE,1008;"
320 !
330 ! FIND THE TEST TONES AND STORE THEIR FREQUENCY AND AMPLITUDE
340 ! IN PREDEFINED VARIABLES
350 !
360 OUTPUT @Sa;"FUNCDEF T_ESTTONES, @"
370 OUTPUT @Sa;"IP;SNGLS;EM;FA 10 MZ;FB 500 MZ;"
380 OUTPUT @Sa;"TS;MKPK HI;MKTRACK ON;"
390 OUTPUT @Sa;"SP30KZ;VB1KZ;TS;"
400 OUTPUT @Sa;"MKTRACK OFF;TS;MKPK HI;"
410 OUTPUT @Sa;"IF MA,GT,RL THEN;"
420 OUTPUT @Sa;" REPEAT;"
430 OUTPUT @Sa;" RL UP;TS;MKPK HI;"
440 OUTPUT @Sa;" UNTIL MA,LE,RL;"
450 OUTPUT @Sa;"ENDIF;"
460 OUTPUT @Sa;"ADD O_PTRANGE,MA,38;"
470 OUTPUT @Sa;"IF AT,LT,O_PTRANGE THEN;"
480 OUTPUT @Sa;" REPEAT;"
490 OUTPUT @Sa;" AT UP;"
500 OUTPUT @Sa;" UNTIL AT,GE,O_PTRANGE;"
510 OUTPUT @Sa;"ENDIF;"
520 OUTPUT @Sa;"MKRL;TS;"
530 OUTPUT @Sa;"MOV T_ONE,MF;"
540 OUTPUT @Sa;"MOV T_ONEAMP,MA;"
550 OUTPUT @Sa;"MKPX 10DB;"
560 OUTPUT @Sa;"MKPK NH;"
570 OUTPUT @Sa;"MOV T_TWO,MF;"
580 OUTPUT @Sa;"MOV T_TWOAMP,MA;"
590 OUTPUT @Sa;"@";
600 !
610 ! IF THE TEST TONES ARE NOT OF EQUAL AMPLITUDE
```

Program Annotation

Lines 10–200	Program name and description
Line 220	Assign the spectrum analyzer address, 718, as @Sa.
Lines 260–310	Define the variables in the program and set their initial values.
Line 360	Define the function in Lines 370–590 as T_ESTTONES.
Lines 370–590	Set the spectrum analyzer's start frequency to 10 MHz and stop frequency to 500 MHz. Zoom in on the higher amplitude test tone to a 30 kHz span. If the peak of the signal is above the reference level, increase the reference level until the signal peak is at or below it. Set the attenuator for optimum dynamic range, then move the signal peak to the reference level and measure it. Store the signal's frequency value in variable T_ONE and its amplitude value in variable T_ONEAMP. Locate the second test tone, measure it, and store its frequency and amplitude values in variables T_TWO and T_TWOAMP, respectively.

```

620 ! OPERATOR IS PROMPTED TO ADJUST THEM WITHIN 2 dB
630 ! OF EACH OTHER
640 !
650 OUTPUT @Sa;"FUNCDEF E_QUALAMP, @"
660 OUTPUT @Sa;"SUB H_EIGHT,T_ONEAMP,T_TWOAMP;"
670 OUTPUT @Sa;"IF H_EIGHT,LT,0;"
680 OUTPUT @Sa;" THEN SUB H_EIGHT,0,H_EIGHT;"
690 OUTPUT @Sa;"ENDIF;"
700 OUTPUT @Sa;"IF H_EIGHT,GT,2 THEN;"
710 OUTPUT @Sa;" CONTS;DA3072;D3;PU;PA100,600;TEXT /ADJUST TEST TONES FOR
EQUAL/;HD;"
720 OUTPUT @Sa;" PU;PA100,550;TEXT /AMPLITUDE AND PRESS THE HZ KEY/;"
730 OUTPUT @Sa;" SS EP;"
740 OUTPUT @Sa;" EM;SNGLS;TS;MKPK HI;"
750 OUTPUT @Sa;" MOV T_ONE,MF;"
760 OUTPUT @Sa;" MOV T_ONEAMP,MA;"
770 OUTPUT @Sa;" MKPK NH;"
780 OUTPUT @Sa;" MOV T_TWO,MF;"
790 OUTPUT @Sa;" MOV T_TWOAMP,MA;"
800 OUTPUT @Sa;"ENDIF;"
810 OUTPUT @Sa;"@";
820 !
830 ! FIND THE THIRD ORDER PRODUCTS
840 !
850 OUTPUT @Sa;"FUNCDEF P_PRODUCTS, @"
860 OUTPUT @Sa;"IF T_ONE,GE,T_TWO THEN ;"
870 OUTPUT @Sa;" XCH T_ONE,T_TWO;"
880 OUTPUT @Sa;" XCH T_ONEAMP,T_TWOAMP;"
890 OUTPUT @Sa;"ENDIF;"
900 OUTPUT @Sa;"SUB D_IFF,T_TWO,T_ONE;"
910 OUTPUT @Sa;"DIV H_OLD,D_IFF,2;"
920 OUTPUT @Sa;"ADD CF,T_ONE,H_OLD;"
930 OUTPUT @Sa;"IF D_IFF,LT,3000 THEN;"
940 OUTPUT @Sa;" SP DN;"
950 OUTPUT @Sa;"ENDIF;"
960 OUTPUT @Sa;"TS;MOV S_TORE,TRA;"
970 OUTPUT @Sa;"SAVES 2;"
980 OUTPUT @Sa;"@";
990 !
1000 ! MEASURE THIRD ORDER PRODUCTS
1010 !
1020 OUTPUT @Sa;"FUNCDEF M_EASURE, @"
1030 OUTPUT @Sa;"ADD CF,T_TWO,D_IFF;"
1040 OUTPUT @Sa;"SP;DN;DN;TS;"
1050 OUTPUT @Sa;"IF D_IFF,GE,3000 THEN;"
1060 OUTPUT @Sa;" MKPK HI;MKRL;MOV VB,RB;"
1070 OUTPUT @Sa;" VB;DN;TS;MKPK HI;"
1080 OUTPUT @Sa;"ELSE MKN;SP;DN;TS;MKPK HI;"
1090 OUTPUT @Sa;" MKRL;VB;DN;TS;MKPK HI;"
1100 OUTPUT @Sa;"ENDIF;"

```

Line 650 Define the function in Lines 660–810 as **E_QUALAMP**.

Lines 660–810 Measure the difference in amplitude between the test tones. If the difference is less than 0 dB, take the absolute value of the difference. If this absolute value is less than 2 dB, continue to the next function. If it is greater than 2 dB, instruct the operator to adjust the test tones for equal amplitude. Re-measure the frequency and amplitude of the test tones, store the new frequency and amplitude values in variables **T_ONE**, **T_ONEAMP**, **T_TWO** and **T_TWOAMP**.

Line 850 Define the function in Lines 860–980 as **P_PRODUCTS**.

Lines 860–890 If the frequency and amplitude values of the tone higher in frequency are stored in variables **T_ONE** and **T_ONEAMP**, exchange these values with the frequency and amplitude values stored in **T_TWO** and **T_TWOAMP**, respectively. This assures that variable **T_TWO** stores the frequency value of the tone higher in frequency.

Lines 900–980 Measure the difference in frequency between the test tones, store the difference in variable **D_IFF**, and set the center frequency to halfway between the two test tones (**T_ONE** + $\frac{1}{2}$ **D_IFF**). If the value of **D_IFF** is less than 3 kHz, also reduce the frequency span. Store the resulting trace in **S_TORE** and the instrument settings in Register 2.

Line 1020 Define the function in Lines 1030–1160 as **M_EASURE**.

Lines 1030–1040 Add the values of variables **T_TWO** and **D_IFF**, and set the center frequency to the sum. This sum is equal to the frequency of the upper third order IMD product, which appears on the right side of the display.

Lines 1050–1100 If the tones are separated by more than 3 kHz, set the third order IMD product to the reference level and measure its amplitude. If the tone separation is less than 3 kHz, reduce the frequency span. This will also reduce the resolution bandwidth. (Shape factor constraints necessitate the narrower bandwidth, and the reduced scan prevents a lengthy sweeptime.) Set the third order IMD product to the reference level and measure its amplitude.

```

1110 OUTPUT @Sa;"SUB I_MRDBC,MA,T_TWOAMP;"
1120 OUTPUT @Sa;"SUB CF,T_ONE,D_1FF;"
1130 OUTPUT @Sa;"TS;MKPK HI;"
1140 OUTPUT @Sa;"MOV L_EFT,MA;"
1150 OUTPUT @Sa;"SUB I_MLDBC,MA,T_ONEAMP;"
1160 OUTPUT @Sa;"@";
1170 !
1180 ! REPORT RESULTS ON SCREEN
1190 !
1200 OUTPUT @Sa;"FUNCDEF R_EPORT, @"
1210 OUTPUT @Sa;"VIEW TRA;RCLS 2;MOV TRA,S_TORE;"
1220 OUTPUT @Sa;"DA3072;D2;PU;PA300,800;TEXT /INTERMODULATION PRODUCTS/
1230 OUTPUT @Sa;"PU;PA200,750;TEXT /TEST TONE LEVEL = /;DSPLY
T_ONEAMP,5.2;PU;PA 700,750;TEXT /dBm/;"
1240 OUTPUT @Sa;"PU;PA200,700;TEXT /TEST TONE SEPARATION = /;DSPLY
D_1FF,6.0;PU;PA700,700;TEXT /Hz/;"
1250 OUTPUT @Sa;"PU;PA200,630;TEXT /THIRD ORDER/;"
1260 OUTPUT @Sa;"PU;PA200,550;TEXT /LOWER/;PU;PA 564,550;DSPLY
I_MLDBC,5.2;PU;PA700,550;TEXT /dBc/;"
1270 OUTPUT @Sa;"PU;PA200,500;TEXT /UPPER/;PUPA 564,500;DSPLY
I_MRDBC,5.2;PU;PA700,500;TEXT /dBc/;"
1280 OUTPUT @Sa;"PU;PA300,82;TEXT /Press SHIFT 2 Hz to repeat test/;HD;
1290 OUTPUT @Sa;"@";
1300 !
1310 ! THE FOLLOWING REPORTS THAT NO THIRD ORDER
1320 ! PRODUCTS ARE FOUND ABOVE THE NOISE LEVEL
1330 !
1340 OUTPUT @Sa;"FUNCDEF N_OTHIRD, @"
1350 OUTPUT @Sa;"RCLS 2;MOV TRA,S_TORE;"
1360 OUTPUT @Sa;"EM;D3;DA3072;PU;PA100,600;"
1370 OUTPUT @Sa;"TEXT /THIRD ORDER INTERMODULATION PRODUCTS/;"
1380 OUTPUT @Sa;"PU;PA100,550;TEXT /ARE AT OR BELOW THE NOISE LEVEL/;"
1390 OUTPUT @Sa;"PU;PA100,525;TEXT /Press SHIFT 2 Hz to repeat test/;"
1400 OUTPUT @Sa;"@";
1410 !
1420 ! IF NO THIRD ORDER PRODUCTS APPEAR
1430 ! ABOVE THE NOISE LEVEL, THE FOLLOWING
1440 ! BRANCHES THE PROGRAM TO READ OUT
1450 ! THAT THE INTERMOD PRODUCTS ARE
1460 ! AT OR BELOW THE NOISE LEVEL
1470 ! OTHERWISE IT REPORTS THE MEASURED
1480 ! RESULTS.
1490 !
1500 OUTPUT @Sa;"FUNCDEF C Heck, @"
1510 OUTPUT @Sa;"SMOOTH TRA,32;MKMIN;"
1520 OUTPUT @Sa;"MOV N_OISE,MA;ADD N_OISE,N_OISE,15;"
1530 OUTPUT @Sa;"IF L_EFT,LE,N_OISE THEN;"
1540 OUTPUT @Sa;" N_OTHIRD;"
1550 OUTPUT @Sa;" ELSE R_EPORT;"
1560 OUTPUT @Sa;"ENDIF;"
1570 OUTPUT @Sa;"@";

```

Line 1110	Measure the difference between the value in variable T_TWOAMP and the amplitude of the upper third order IMD product, and store the result in variable I_MRDBC . This result is the relative amplitude of the third order IMD product, in dBc from the peak of the higher frequency tone.
Lines 1120–1160	Subtract the values of variables T_ONE and D_1FF , and set the center frequency to the difference. This difference is equal to the frequency of the lower third order IMD product, which appears on the left side of the display. Measure the amplitude of the IMD product, and store it in variable L_EFT . Measure the difference between the value in variable T_ONEAMP and the amplitude of the third order IMD product, and store the result in variable I_MLDBC . This result is the relative amplitude of the third order IMD product, in dBc from the peak of the lower frequency tone.
Line 1200	Define the function in Lines 1210–1290 as R_EPORT .
Lines 1210–1290	Display the user-defined trace, S_TORE , the settings stored in Register 2, the test tone amplitude and separation, and the relative amplitude values (in dBc) of the upper and lower third order IMD products. Prompt the user to press shift 2 Hz to re-run the test.
Line 1340	Define the function in Lines 1350–1400 as N_OTHIRD .
Lines 1350–1400	Display the user-defined trace, S_TORE , and the settings stored in Register 2. Report the third order IMD products are at or below the noise level.
Line 1500	Define the function in Lines 1510–1570 as C Heck .
Lines 1510–1570	Smooth the trace. The minimum level of the smoothed trace is an approximation of the average noise level. Compare this minimum trace level to the amplitude of the lower third order IMD product, stored in variable L_EFT . If L_EFT is 15 dB higher than the approximate noise level, branch to R_EPORT . If L_EFT is not 15 dB higher than the approximate noise level, branch to N_OTHIRD .

```

1580 !
1590 ! MAIN FUNCTION
1600 !
1610 OUTPUT @Sa;"FUNCDEF T_HIRDIMOD, @"
1620 OUTPUT @Sa;"T_ESTTONES;E_QUALAMP;P_PRODUCTS;M_EASURE;C_HECK;"
1630 OUTPUT @Sa;"@";
1640 !
1650 ! DEFINE THE PROGRAM AS SOFTKEY TWO
1660 !
1670 OUTPUT @Sa;"KEYDEF 2,T_HIRDIMOD;"
1680 END

```

Line 1610	Define the main function in Line 1620 as T_HIRDIMOD .
Line 1620	Specify the sequence of the functions to test for third order IMD products: find the test tones, check for equal amplitude, locate and measure the third order IMD products, and ensure the products are above the noise level. If the products are above the noise level, report the measured results, or else report they are too low to be measured.
Line 1670	Make the program accessible from the front panel under softkey 2.

Program Execution

To execute the program from the analyzer front panel, press **[SHIFT][2][Hz]**. Or, to execute it from a controller, type:

```
OUTPUT 718;"T_HIRDIMOD;"
```

and press **[EXECUTE]**.

Application Example

To measure the internal third order IMD of an amplifier:

Before testing an amplifier (or any other device), run the program without the amplifier in the system to ensure the system is not producing intermodulation distortion products. If the program results show the products are above the noise, increase the attenuation at the output of the signal sources or check the low-pass filters to ensure they are not passing any test-tone harmonics. When the system distortion is eliminated, insert the amplifier between the output of the combiner and the input of the analyzer as shown in the section, Test Setup.

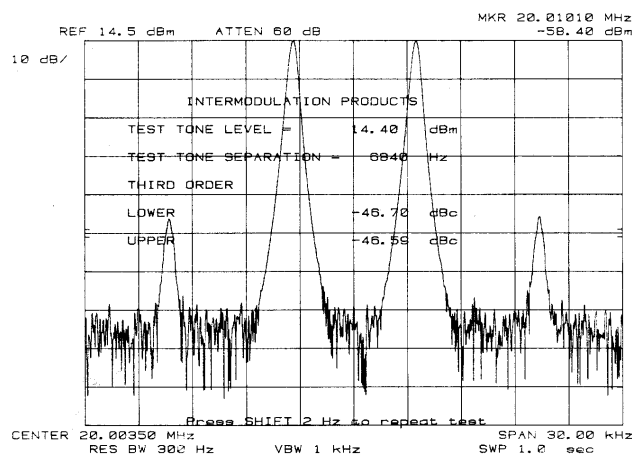


Figure 3. Example of T_HIRDIMOD Results

By internet, phone, or fax, get assistance with all your test and measurement needs.

Online Assistance
www.agilent.com/find/assist

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

Copyright © 1985, 2000 Agilent Technologies
 Printed in U.S.A. 10/00
 5954-2701



Agilent Technologies

Innovating the HP Way