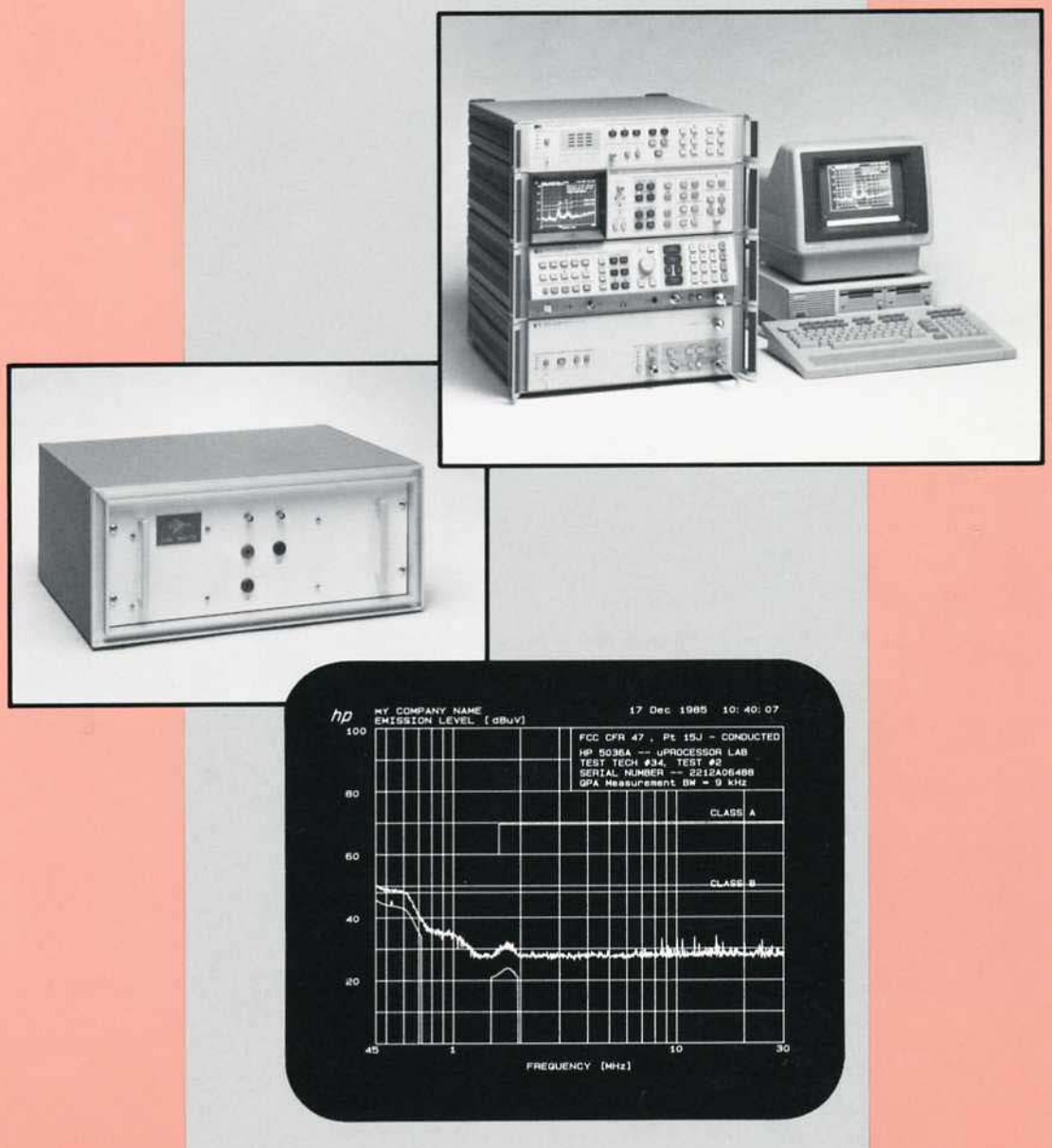
Application Note 331-1

AUTOMATIC CISPR EMI TESTING

for CONDUCTED EMISSIONS
Using the HP 85864B/C EMI Measurement Software



HEWLETT PACKARD

APPLICATION NOTE 331-1

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CONTENTS

1 INTRODUCTION

BACKGROUND

Reduction of electromagnetic interference (EMI) from computing devices has been the goal of governmental regulatory bodies for many years. The Comite International Special des Pertabations Radioelectriques (CISPR) set forth some recommendations for measuring these interfering emissions, and these guidelines have been adopted by many regulatory agencies.

The CISPR guidelines have been followed by the German FTZ/VDE, and their testing criteria have become standards for others to follow.

In April, 1976, the Federal Communication Commission (FCC) issued a rule-change proposal. The purpose of the proposal was to redefine and clarify rules and regulations governing radiation devices. These rule changes were finally implemented on October 1, 1983, and they represent the FCC's implementation of the CISPR guidelines.

As a result of all these regulations, manufacturers of computing devices must meet strict requirements governing the level of radio frequency interference their devices may emit. Testing a device to these requirements can be time consuming, and requires a characterized and carefully set up test facility. However, placing greater emphasis on the elimination of emissions in the design stages of a product often reduces the final compliance tests to mere formalities.

This application note describes test methods used to comply with the CISPR-based regulations of the FCC and FTZ/VDE for conducted emissions from the computing devices and their peripherals. These test methods can be used during equipment design and after to ensure compliance with the various EMI emission specifications.

PURPOSE

This application note describes the HP 85864B EMI Measurement Software and how to use it with the HP 8573A/8574A Spectrum Analyzer/EMI Receivers in order to:

- Reduce test time by scanning wide frequency ranges.
- Analyze emissions measured using the "quick-look" capability of the spectrum analyzer.
- Report test results using plots and printouts of measurement data that document design results and verify compliance.

HOW TO USE THIS APPLICATION NOTE

The procedures detailed in this application note include equipment requirements, test configurations, control settings, and calibration procedures.

The test methods described in this note are for meeting FCC Rules 47 CFR Part 15J and VDE 0871 EMI compliance specifications. Both regulations are based on CISPR recommendations. Each regulatory agency, however, has different product definitions, frequency range coverage, and specification limits. Therefore, this application note covers each regulation separately. The procedures given are general and may be applied to other specifications. The methods described are:

FCC Conducted Emissions — 450 kHz to 30 MHz
VDE Conducted Emissions — 10 kHz to 30 MHz

The test procedures in this note are organized as follows.

Instruments and Accessories
Equipment Configuration and Test Environment
Test Setup Table
Preview of the Measurement Range
Making a Peak Measurement

Each measurement generally consists of calibrating the receiver, connecting the signal pickup device, measuring the peak emissions, and observing the resultant spectrum display.

The specification limits and details of a given method are subject to change as the applicable standards change. However, the methods presented here should allow you to implement such changes with a minimum of difficulty. Details of how to add a test or test results to the EMI software library are given in the measurement and post measurement analysis sections.

II MEASUREMENT EQUIPMENT

EQUIPMENT REQUIREMENTS

The HP 85864B/C EMI Measurement software makes full use of the capabilities of a spectrum analyzer/EMI receiver, and requires a minimum of additional equipment for making EMI measurements. A spectrum analyzer/EMI receiver consists of:

HP 85650A Quasi-Peak Adapter for the receiver bandwidths and the quasi-peak detection required in CISPR-based EMI testing

HP 85685A RF Preselector for swept-tuned filters to provide overload protection, increased sensitivity, and amplitude calibration

HP 8567A, HP 8568B or HP 8566B Spectrum Analyzer

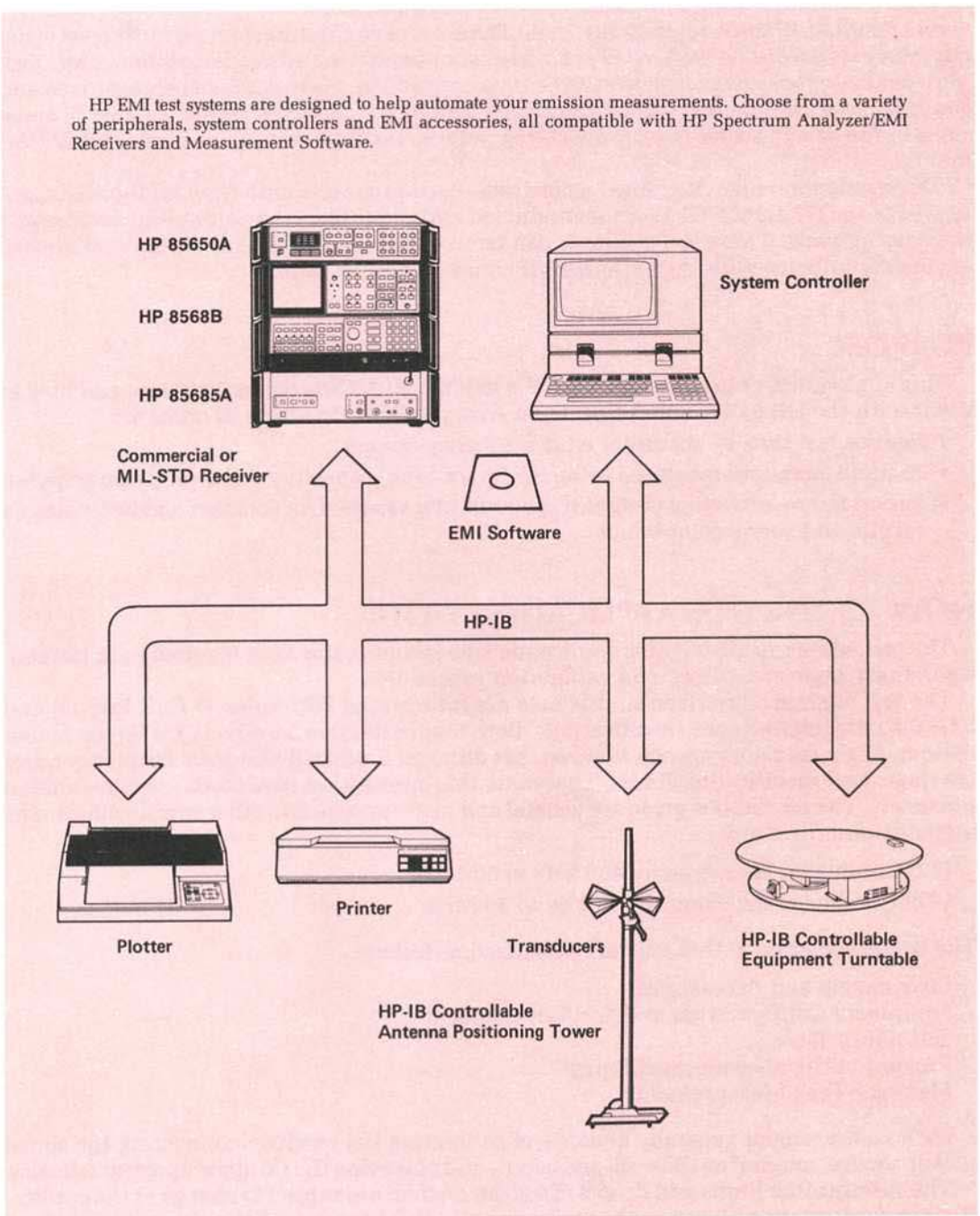


Figure 1. Measurement System Configuration Showing Front-Panel Interconnections (see Appendix E for Rear-Panel Interconnections)

The measuring equipment and computer requirements for using the EMI software are shown in Table 1. Figure 1 shows the front panel interconnections for a typical test setup. See Appendix E for details of rear-panel interconnections. Any additional equipment required to perform a CISPR-based test (such as a transducer) is listed in the test procedure. Recommended accessories for the measurement system are also given in the table below.

NOTE: The HP 8573A Spectrum Analyzer/EMI Receiver is the EMI test receiver specified in the test procedures. However, the HP 8574A or the combination of a spectrum analyzer, quasi-peak adapter and RF preselector is a direct substitute for the HP 8573A.

NOTE: The HP 85685A RF Preselector works only with the HP 8567A, HP 8568B or HP 8566B Spectrum Analyzer. If an HP 8568A or 8566A is to be used for these tests, the RF preselector cannot be used. However, a modification kit is available from Hewlett-Packard to upgrade an HP 8568A or 8566A Spectrum Analyzer to a "B" model. The upgrade kit model numbers are:

HP 8568A + 01K for the HP 8568A

HP 8566A + 01K for the HP 85b6A

Contact your local representative for price, delivery and additional information.

Table 1. Equipment Recommendations for using the HP 85864B EMI Software

MEASURING EQUIPMENT:
Spectrum Analyzer/EMI Receiver[1,2] ..... HP 8573A or 8574A

COMPUTER REQUIREMENTS:
Computer ..... HP 9000 Series 200 or 300
Language BASIC 3.0 (85864B) or ..... BASIC 4.0 (85864C)
additional RAM[3] ..... one (1) HP 98257A (1 MByte) and one (1) HP 98256A (256 kByte)

RECOMMENDED ACCESSORIES:
Graphics Plotter ..... HP 7550A, 7475A, or 7440A
Graphics Printer ..... HP 2225A, 2673A, or 2671G

1. HP 8573A Spectrum Analyzer/EMI Receiver consists of:
   Spectrum Analyzer ..... HP 8567A
   Quasi-peak Adapter ..... HP 85650A
   RF Preselector ..... HP 85685A
   System Cabinet (optional) ..... HP 85900A

2. HP 8574A Spectrum Analyzer/EMI Receiver consists of:
   Spectrum Analyzer ..... HP 8568B
   Quasi-peak Adapter ..... HP 85650A
   RF Preselector ..... HP 85685A
   System Cabinet (optional) ..... HP 85900A

3. An additional HP 98256A (256 kByte) memory board is required when using the model 236 color computer, giving a total computer memory of 1.3 Mbyte. The additional memory is recommended when using the model 216 or 226 computers to allow for the addition of user-written subprograms.

Typical EMI Receiver System Configuration

CALIBRATING THE EMI TEST RECEIVER

A test receiver consisting of an HP 8567A (or 8568B) Spectrum Analyzer, an HP 85685A RF Preselector, and an HP 85650 Quasi-Peak Adapter meets the EMI receiver recommendations of CISPR Publication 16*. Proper calibration of this test receiver guarantees ± 2 dB absolute amplitude accuracy over the frequency range of 10 kHz to 1 GHz. The following sections briefly discuss how to calibrate the test receiver. For a more detailed discussion see the RF Preselector Operating Manual.

*(*CISPR Publication 16 is the Comite International Special des Pertabations Radioelectrique specification for radio interference measuring apparatus and measurement methods.)*

Calibrating the Spectrum Analyzer

The frequency and amplitude calibration of the HP 8568B Spectrum Analyzer is adjusted from the front panel using the CAL OUTPUT signal as a reference. Verify this calibration once per day. In order to check the calibration, complete the following steps:

1. Connect the spectrum analyzer CAL OUTPUT to the preselector input 2. Connect the RF preselector output to the spectrum analyzer input. Activate the bypass function on the preselector.

NOTE: The HP 8568B has two input connectors; connect the preselector to the input corresponding to the frequency range of interest. If the low frequency spectrum analyzer input is used, use a BNC type cable in place of the N type hard cable supplied with the RF preselector.

2. Press [RECALL] [8] on the spectrum analyzer. Adjust AMPTD ADJ on the front panel for a −10.00 dBm ±0.02 dB marker amplitude reading.
3. Press [RECALL] [9] on the spectrum analyzer. Adjust FREQ ZERO on the front panel for maximum signal amplitude.

Calibrating the Receiver

The RF preselector has an internal comb generator which is used to amplitude-calibrate the measurement system. To calibrate the measurement receiver, first make sure all equipment interconnections have been made. Note that the RF preselector and the HP 8568B have two inputs. Be sure to select the proper input for the frequency range of the calibration to be performed. Set the HP 8567A/8568B, 85685A, and 85650A settings for the CISPR band (B, C, or D) to be used, as shown in Table 2. Select LIN display scale. Press CAL SEQUENCE [START] on the preselector. The calibration sequence is finished when the analyzer has been reset to the original start and stop frequencies. The display scale can be set to LOG (10, 5, 2, or 1dB) for peak measurements or LIN for quasi-peak detector measurements, and the display units can be changed from dBm to dBμV by pressing [SHIFT] C [AUTO] on the spectrum analyzer.

Table 2. Calibration Settings for CISPR-based Emission Measurement

Instrument Settings	CISPR BAND[1]		
	B	C	D
Frequency Range[2]	0.15-30 MHz	30-300 MHz	0.3-1 GHz
Quasi-Peak Bandwidth[3]	9 kHz	120 kHz	120 kHz
Quasi-Peak Detector	OFF	OFF	OFF
S.A. Bandwidth	100 kHz	1 MHz	1 MHz
S.A. Video Bandwidth	1 kHz	3 kHz	3 kHz
S.A. Input Atten.	10 dB	0 dB	0 dB
Preselector Atten.	20 dB	10 dB	10 dB
Preselector Input	INPUT 1	INPUT 2	INPUT 2

1. For CISPR band A (10-150 kHz), spectrum analyzer calibration is adequate to ensure ±2 dB amplitude accuracy.
2. Use the limits of the frequency range for the spectrum analyzer start and stop frequencies.
3. This bandwidth is automatically selected when the quasi-peak adapter frequency band is selected.

III PRE-MEASUREMENT OPTIONS

This section illustrates how to use the HP 85864B/C EMI software to annotate the spectrum analyzer display and add limit line(s) to the data plot. The enhanced display of measurement data is then ready to plot or print for a complete record of the measurement.

The EMI test title in the Test Setup table plus the time and date from the controller are always displayed on the test record. Three additional test labels and up to three limit lines can be added to the data display for your test reports.

A company or facility name and two titles (two lines each, for adding the name or model number of equipment under test (EUT), serial number, operator I.D., etc.) are the three user-entered labels available.

The limit table in the Test Setup section of the program is used to add up to three limit lines to meet the specification of the test you are performing. The completed table can be added to the Limit Library for later use in any measurement setup.

For more information on features of the EMI Measurement Software, consult the software operation manual.

LABELING THE TEST RECORD

Entering a Facility Name

From the TOP LEVEL menu (see Figure 2)

- Press [UTILITY] softkey
- Press [NAME] softkey
- Type the desired name (i.e., MY COMPANY); press [ENTER]

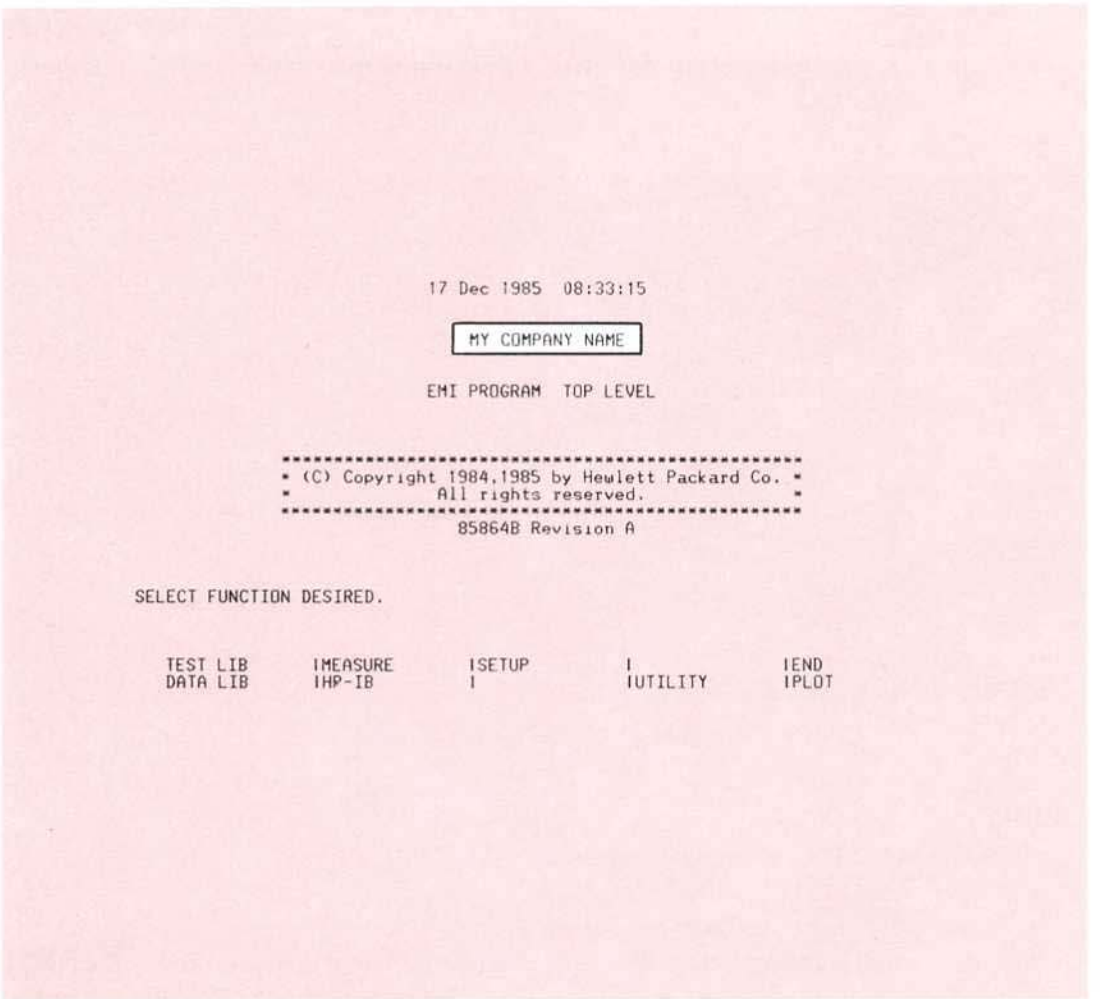


Figure 2. Top Level Menu Display

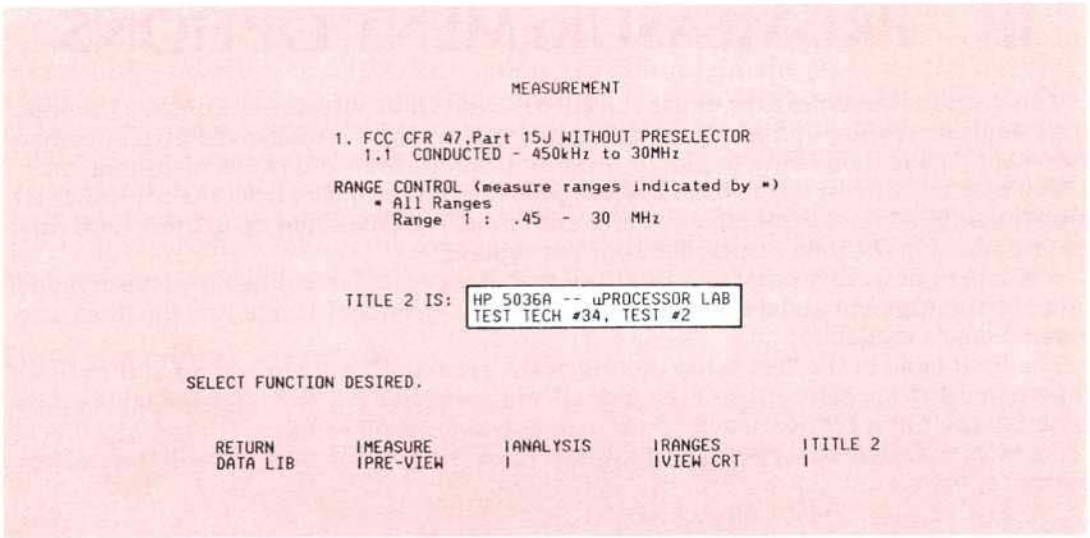


Figure 3. Measurement Menu Display

Entering Titles: (Figure 3 applies to 85864B only)

Title 2

From the TOP LEVEL menu (see Figure 2)

- Press **MEASURE** softkey
- Press **TITLE 2** softkey (see Figure 3)
- Type desired information for line 1 (i.e., device name or model number); press **ENTER**
- Type desired information for line 2 (i.e., operator name or I.D. number); press **ENTER**

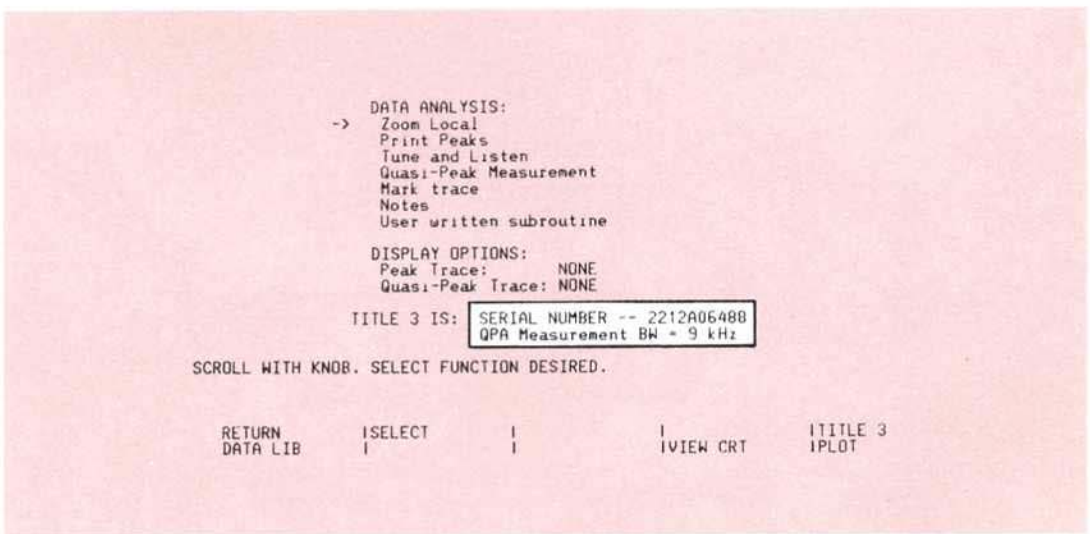


Figure 4. Analysis Menu Display

Title 3

From the MEASURE menu (see Figure 3)

- Press **ANALYSIS** softkey
- Press **TITLE 3** softkey (see Figure 4)
- Type desired information for line 1 (i.e., serial number of device); press **ENTER**
- Type desired information for line 2 (i.e., Measurement BW = 120kHz); press **ENTER**

MY COMPANY NAME
LIMIT TABLE
Limit Title : CLASS A
Number of Points : 4

Point	Frequency (MHz)	Amplitude
1	.45	60
2	1.6	60
3	1.6	69.5
4	30	69.5

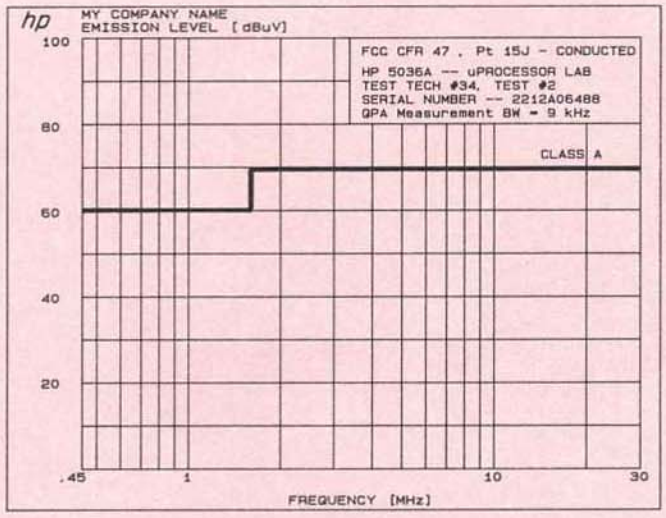


Figure 5. Limit Table and Spectrum Analyzer Display of Limit

THE LIMIT LINE

From the TOP LEVEL menu (see Figure 2)

- Press **SETUP** softkey
- Position cursor window at Limit 1 with computer keyboard rotary knob or cursor position keys
- Press **GET LIMIT** softkey
- Enter limit line, number of limit points, frequency and amplitude of each point (see Figure 5)
- Press **LIBRARY** softkey
- Press **STORE** softkey; and **ENTER** (Default file name is the same as the limit title from table)
- Press **RETURN** softkey

The new limit has been added to your Limit Library and your test. Press **RETURN** to get to the TOP LEVEL menu and then select **MEASURE** to run your test.

THE TRANSDUCER CALIBRATION FACTORS

The HP 85864B/C EMI software sets the spectrum analyzer display units to dBμV (decibels above 1 microvolt). The Transducer Table can be used for converting to other display units, such as dBm (decibels above 1 milliwatt). Figure 6 shows Range 1 of a test setup table. To reach the transducer table, move the selection box to the desired transducer label as shown, and press the **GET TRANS** softkey. Figure 7 shows a typical transducer table. To convert the displayed units of measure to dBm, for example, enter the start and stop frequencies for the measurement range and −107 as the transducer factor. The program uses this information to display the measured data in dBm.

The transducer used for CISPR-based conducted emission testing is a Line Impedance Stabilization Network (LISN). The transducer factors for this pickup device are assumed to be unity. This may not always be the case, especially at frequencies below 1 MHz. A measurement of the factors for a given device should be made to confirm the calibration factors. The measured transducer factors should then be entered in the transducer table (see Figure 7.) The program does a straight line interpolation between data points.

NOTE: All calibrations assume zero dB loss in the interconnecting cables. When this is not the case, cable losses and frequency-response variations of any additional external devices must be taken into account. These variations must be added to the data entered in the transducer table shown in Figure 7.

```
Range 1 of 1
  Start Freq(MHz): .45
  Stop Freq (MHz): 30
  Transducer     : NONE
  Ampl Name      : NONE
  Ampl Gain  (dB): 0
  SA Input       : RIGHT
  Presel Input   : LEFT
  Quasi-Peak Bw  : 9 kHz
  SA Res Bw  (Hz): 100000
  Video Bw   (Hz): 100000
  Ref. Lvl (dBuV): 100
  Int Atten  (dB): 10
  Presel Atten   : 20
  Ext Atten  (dB): 0
  # Setups       : 1
  # Sweeps/Setup : 1
  Msg,Sub,Cont   : MESSAGE
         Line #1 : CONNECT LISN TO THE LEFT INPUT
         Line #2 : ON THE PRESELECTOR
```

Figure 6. Test Setup Table, Range 1

```
MY COMPANY NAME
TRANSDUCER TABLE
Transducer Title : EMCO 3825/2R -- LISN
Sign of Trans.   : PLUS
Number of Points : 6
```

Point	Frequency (MHz)	Trans Factor		CABLE LOSS		COMBINED FACTOR
1	.01	3		0		3
2	.04	2.5		0		2.5
3	.1	1.5	+	0	=	1.5
4	.2	.5		.1		.6
5	.45	0		.25		.25
6	30	0		.75		.75

Figure 7. Example of a Transducer Table

IV FCC CONDUCTED EMISSION TEST
450 KHz TO 30 MHz

This test covers specifications given in FCC Rules 47 CFR Part 15, Subpart J, for evaluating the electromagnetic characteristics of computing devices and their peripherals. The objective of this test is to measure interference emissions conducted on the power leads of a test device over the frequency range of 450 kHz to 30 MHz.

INSTRUMENTS AND ACCESSORIES

Description	Model #	Manufacturer
Spectrum Analyzer/EMI Receiver	HP 8573A	Hewlett-Packard
LISN	EMCO 3825/2R	Electro Mechanics Co.
Recommended for improved power main filtering:		
Feedthru Capacitor 10 μF	6512-106R	Solar
Isolation Transformer		

EQUIPMENT CONFIGURATION AND TEST ENVIRONMENT

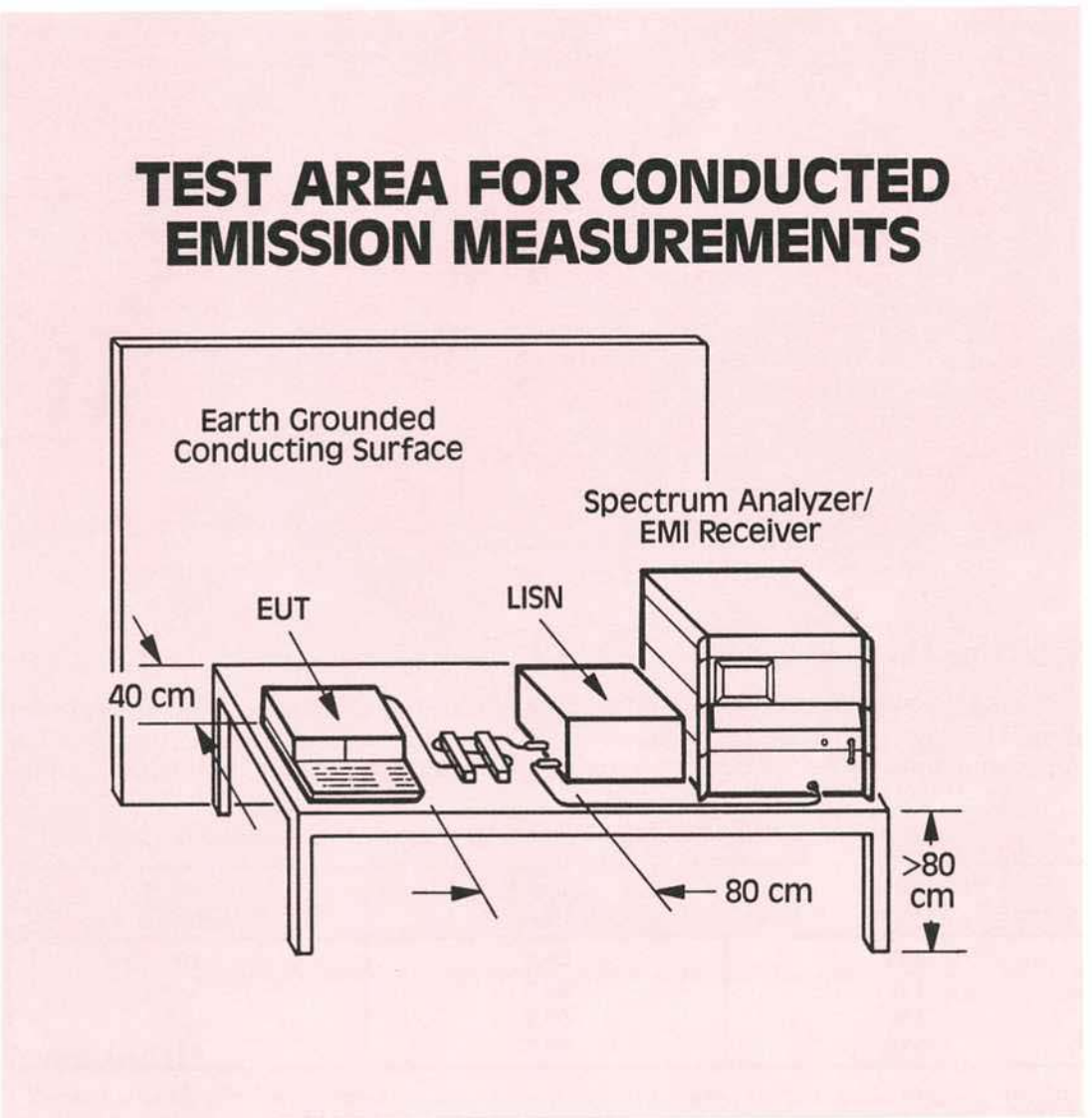


Figure 8. Equipment Configuration and Test Environment for FCC Conducted Emission Measurement on Power Leads

```
MY COMPANY NAME
TEST SETUP TABLE
-------------------------------------------------
Library File : CONDUCTED - 450 kHz to 30 MHz

Display title     : FCC CFR 47 , Pt 15J - CONDUCTED
Units label       : dBuV
Disp Ref Lvl (dB): 100
Test Type         : PEAK
Freq Uncert.  (%): 1
Min Swp Time/Oct : 3

Range 1 of 1
  Start Freq(MHz): .45
  Stop Freq (MHz): 30
  Transducer      : NONE
  Ampl Name       : NONE
  Ampl Gain  (dB): 0
  SA Input        : RIGHT
  Presel Input    : LEFT
  Quasi-Peak Bw   : 9 kHz
  SA Res Bw  (Hz): 100000
  Video Bw   (Hz): 100000
  Ref. Lvl (dBuV): 100
  Int Atten  (dB): 10
  Presel Atten    : 20
  Ext Atten  (dB): 0
  # Setups        : 1
  # Sweeps/Setup : 1
  Msg,Sub,Cont    : MESSAGE
         Line #1 : CONNECT LISN TO THE LEFT INPUT
         Line #2 : ON THE PRESELECTOR

Limit #1 Label    : CLASS A
Limit #2 Label    : CLASS B
Limit #3 Label    : NONE

------------ Test Setup Table Notes -------------
```

Figure 9. FCC Conducted Test Setup Table Supplied with EMI Software Library

Selecting the Test Limit

The test limits for FCC Rules 47 CFR Part 15J, Class A computing devices (commercial use) and Class B computing devices (residential use) are shown in Table 3. See Section III of this application note for instructions on entering limits into the software limit table.

Table 3. FCC Rule 47 CFR Part 15J Limits for Conducted Emission Testing

Frequency (MHz)	Class A (dBμV)	Class B (dBμV)
0.45	60.0	48
1.6	60.0	
1.6	69.5	
30.0	69.5	48

NOTE: The values given in Table 3 are the end points for straight line segments drawn on a log-frequency plot. Figure 10 shows the specified limit values entered into a limit table and how that limit appears on the spectrum analyzer display.

MY COMPANY NAME
LIMIT TABLE
Limit Title : CLASS B
Number of Points : 2

Point	Frequency (MHz)	Amplitude
1	.45	47.96
2	30	47.96

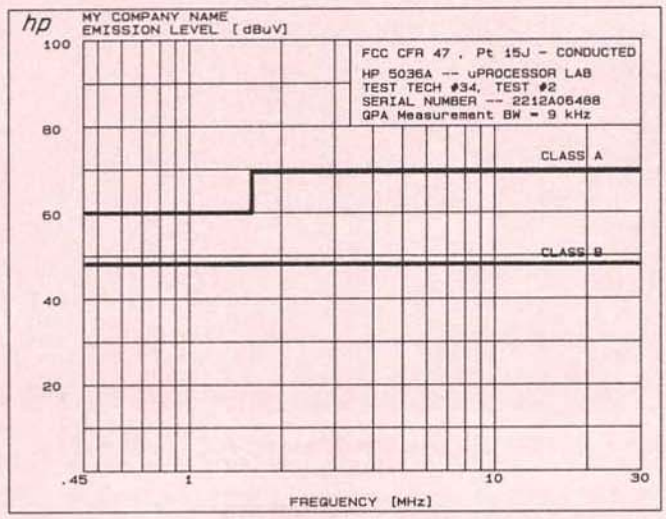


Figure 10. FCC Conducted Emission Limit Table and Resulting Spectrum Analyzer Display

Adding a Test Setup to the Test Library

If you modify a test or enter your own test parameters into the test setup table, you need to store the new test setup into a test library. Do not change or modify the test library that is supplied with the EMI Measurement Software. Keep this master library. It is recommended that you initialize a separate disc to be used as your working test library. Store all test modifications and measurement results on this disc. A thorough explanation of initializing a disc and creating a new library is found in the software operation manual. The following procedure stores your new setup on your disc.

- From the TOP LEVEL menu, press **TEST LIB**
- Press **STORE** softkey
- **SELECT** the test file heading desired or press **ADD HDR** to add a new header to the library
- Type the name of your test file at the prompt and press **ENTER**
- Your test setup table is now added to the library.

To save your measurement data press **DATA LIB** from the top level menu and follow the steps described above.

PREVIEW OF THE MEASUREMENT RANGE

A real-time preview of the measurement range can be made with the software. This feature is useful for taking a quick look at the measurement range on order to:

- Insure that the equipment has been connected properly
- Compare the emissions to the composite limit line
- Test for overload of the receiver
- Calibrate the receiver

Figure 11 shows the preview selection screen. With the computer data knob, position the arrow adjacent to the transducer range to be previewed. Figure 12 shows the spectrum analyzer preview display with composite limit lines.

```
                              PRE-VIEW

          Select the Measurement Range to be displayed on
          the Spectrum Analyzer. Display will be linear
          frequency with coupled Sweeptime. Res BW, Video
          BW, Ref Level, and Attenuation are per TEST SETUP.
          Displayed data is NOT corrected. Limit lines are
          corrected for transducer factors, attenuation,
          and preamp gain. Limit lines appear for PEAK
          traces and for one range only.

             SELECT RANGE TO CHECK.
               All ranges (coupled)
           -> Range  1 :  .45  -  30  MHz


SCROLL WITH KNOB. SELECT FUNCTION DESIRED.

  RETURN          |SELECT          |              |              |
                  |                |              |              |PLOT
```

Figure 11. PRE-VIEW Selection Screen for FCC Conducted Test

- From the TOP LEVEL MENU, press **MEASURE**
- Select the PRE-VIEW function
- Select transducer range of interest (see Figure 11)
- Connect the RF preselector output to the spectrum analyzer input
- Connect the input cable to the appropriate preselector input

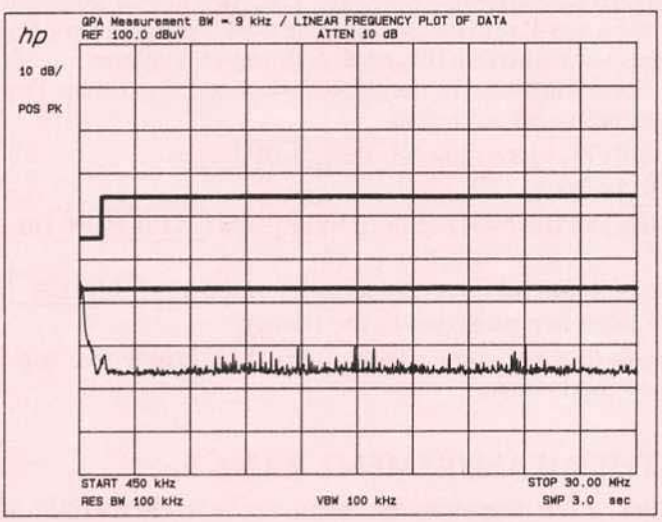


Figure 12. Spectrum Analyzer Display for Preview Mode Showing Limit Lines

TESTING FOR OVERLOAD

The RF preselector 3 dB LIN push button is used to check for overload. While in the preview mode, press the 3 dB switch and observe the amplitude level of the signals on the spectrum analyzer display. There should be a less-than-1-dB change in the observed peak level of signals that are at least 10 dB above the noise floor. If a change in amplitude does occur, then increase the preselector input attenuation by 10 dB and repeat the 3 dB test. Continue to add attenuation until the signals behave linearly. Use the least amount of attenuation necessary to cause linear signal-amplitude change. Enter this attenuator setting into the test setup table before making the measurement.

CALIBRATING THE RECEIVER

The receiver can be conveniently calibrated in the preview mode. The spectrum analyzer/EMI receiver can be placed in local operation by pressing the [LOCAL] softkey. The appropriate front-panel settings for the measurement range were made by the software when PRE-VIEW was selected. To calibrate the system, connect the preselector comb-generator output to the correct preselector input (lighted LED), and press the CAL SEQUENCE [START] key on the preselector front panel. Repeat this procedure for each measurement range. See Section II of this application note for more information on calibrating the test receiver.

MAKING A PEAK MEASUREMENT

After the test setup has been completed and the measurement range has been previewed, the next step is to perform a measurement. The first measurement made by the software uses the spectrum analyzer peak detector. This is accomplished by simply pressing [MEASURE] (press twice if starting from the TOP LEVEL menu). The test record is drawn on the computer display and the measuring receiver is initialized. The computer will beep, prompt the operator to connect the transducer (a LISN) to the correct preselector input, and press [CONTINUE]. The measurement will proceed, with measurement data drawn on the computer display for viewing by the operator. If the data seems invalid, the test can be terminated by pressing [ABORT] at any time during the measurement. When the measurement is complete, press [CONTINUE] and the corrected peak measurement data will be plotted on the spectrum analyzer display for viewing. The program is now at the ANALYSIS menu screen. Post measurement analysis of the data can be performed, including quasi-peak detector measurement of specific signals.

Saving the Measurement Data

The measurement data can be saved on your library disc for later retrieval by following these steps:

- From the ANALYSIS menu, press [DATA LIB]
- Press the [STORE] softkey
- [SELECT] the test file heading desired or press [ADD HDR] to add a new header to the library
- Type a name for your data file (i.e., test #3, device #123 — 6/8/85); press [ENTER]
- Press [RETURN]

V VDE 0871 CONDUCTED EMISSION TEST
10 kHz TO 30 MHz

This test covers specifications given in VDE 0871/6.78 for evaluating the electromagnetic characteristics of computing devices and their peripherals. The objective of this test is to measure interference emissions conducted on the power leads of a test device over the frequency range of 10 kHz to 30 MHz.

INSTRUMENTS AND ACCESSORIES

Description	Model #	Manufacturer
Spectrum Analyzer/EMI Receiver	HP 8573A	Hewlett-Packard
LISN	EMCO 3825/2R	Electro Mechanics Co.

Recommended for improved power-main filtering:

Feedthru Capacitor 10 μF	6512-106R	Solar
Isolation Transformer		

EQUIPMENT CONFIGURATION AND TEST ENVIRONMENT

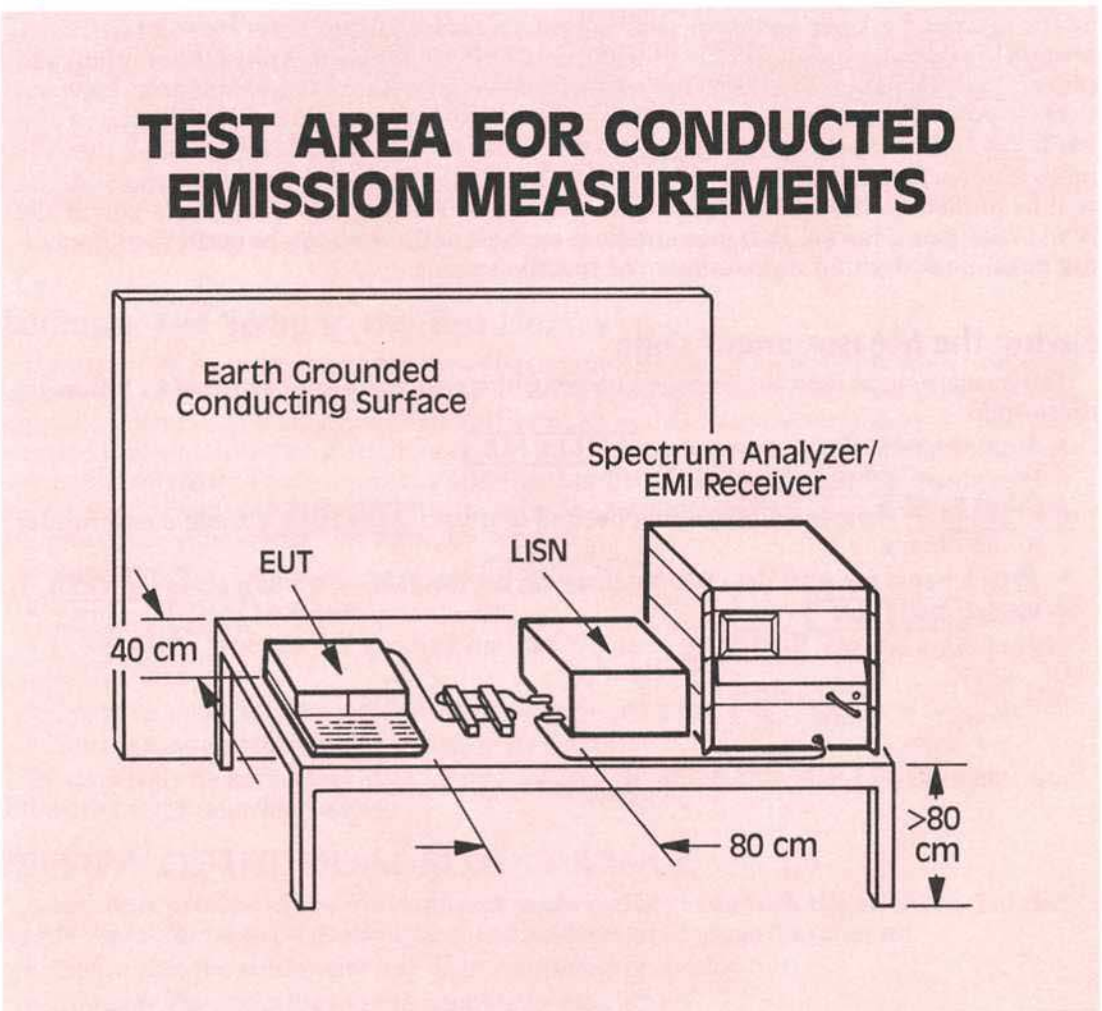


Figure 13. Equipment Configuration and Test Environment for VDE 0871 Conducted Emission Measurement on Power Leads

TEST SETUP TABLE

```
MY COMPANY NAME
TEST SETUP TABLE
-------------------------------------------------
Library File : CONDUCTED - 10kHz to 30MHz

Display title     : VDE 0871 / 6.78 - CONDUCTED
Units label       : dBuV
Disp Ref Lvl (dB): 100
Test Type         : PEAK
Freq Uncert.  (%): 1
Min Swp Time/Oct : 3

Range 1 of 2
  Start Freq(MHz): .01
  Stop Freq (MHz): .15
  Transducer      : NONE
  Ampl Name       : NONE
  Ampl Gain  (dB): 0
  SA Input        : LEFT
  Presel Input    : LEFT
  Quasi-Peak Bw   : 200 Hz
  SA Res Bw  (Hz): 3000
  Video Bw   (Hz): 3000
  Ref. Lvl (dBuV): 90
  Int Atten  (dB): 10
  Presel Atten    : 20
  Ext Atten  (dB): 0
  # Setups        : 1
  # Sweeps/Setup : 1
  Msg,Sub,Cont    : MESSAGE
         Line #1 : CONNECT LISN TO THE LEFT INPUT
         Line #2 : ON THE PRESELECTOR

Range 2 of 2
  Stop Freq (MHz): 30
  Transducer      : NONE
  Ampl Name       : NONE
  Ampl Gain  (dB): 0
  SA Input        : LEFT
  Presel Input    : LEFT
  Quasi-Peak Bw   : 9 kHz
  SA Res Bw  (Hz): 100000
  Video Bw   (Hz): 100000
  Ref. Lvl (dBuV): 100
  Int Atten  (dB): 10
  Presel Atten    : 20
  Ext Atten  (dB): 0
  # Setups        : 1
  # Sweeps/Setup : 1
  Msg,Sub,Cont    : CONTINUE

Limit #1 Label    : CLASS A
Limit #2 Label    : CLASS B
Limit #3 Label    : NONE
```

Figure 14. VDE Conducted Test Setup Table Supplied with EMI Software Library

Selecting the Test Limit

The test limits for VDE 0871/6.78 Level A/C computing devices (individual license) and Level B computing devices (general license) are shown in Table 4. See Section III of this application note for instructions on entering limits into the software limit table.

Table 4. VDE 0871/6.78 Limits for Conducted Emission Testing

Frequency (MHz)	Level A/C (dBμV)	Level B (dBμV)
0.01	N/A	79.0
0.15	N/A	58.0
0.15	66.0	54.0
0.50	66.0	54.0
0.50	60.0	48.0
30.00	60.0	48.0

NOTE: The values given in Table 4 are the end points for straight line segments drawn on a log frequency plot. Figure 20 shows the specification limit values entered into a limit table, and how the limit appears on the spectrum analyzer display.

MY COMPANY NAME
LIMIT TABLE
Limit Title : CLASS B
Number of Points : 6

Point	Frequency (MHz)	Amplitude
1	.01	79
2	.15	58
3	.15	54
4	.5	54
5	.5	48
6	30	48

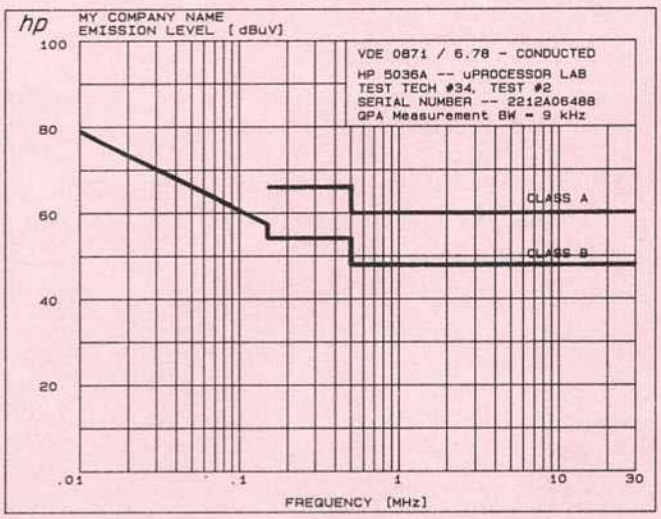


Figure 15. VDE Conducted Emission Limit Table and Resulting Spectrum Analyzer Display

Adding a Test Setup to the Test Library

If you modify a test or enter your own test parameters into the test setup table, you need to store the new test setup in a test library. Do not change or modify the test library that is supplied with the EMI Measurement Software. Keep this as a master library. It is recommended that you initialize a separate disc to be used as your working test library. Store all test modifications and measurement results on this disc. A thorough explanation of initializing a disc and creating a new library is found in the software operation manual. The following procedure stores your new setup on your disc.

- From the TOP LEVEL Menu, press **TEST LIB**
- Press **STORE** softkey
- **SELECT** the test file heading desired or press **ADD HDR** to add a new header to the library
- Type the name of your test file at the prompt and press **ENTER**
- Your test setup table is now added to the library.

To save your measurement data press **DATA LIB** from the TOP LEVEL menu and follow the steps described above.

PREVIEW OF THE MEASUREMENT RANGE

A real-time preview of the measurement range can be made with the software. This feature is useful for taking a quick look at the measurement range on order to:

- Insure that the equipment has been connected properly
- Compare the emissions to the composite limit line
- Test for overload of the receiver
- Calibrate the receiver

Figure 16 shows the preview selection screen. With the computer data knob, position the arrow adjacent to the transducer range to be previewed. Figure 17 shows the spectrum analyzer preview display with limit lines and emissions present.

Before connecting the input cable to the spectrum analyzer, do the following:

```
                              PRE-VIEW

        Select the Measurement Range to be displayed on
        the Spectrum Analyzer. Display will be linear
        frequency with coupled Sweeptime. Res BW, Video
        BW, Ref Level, and Attenuation are per TEST SETUP.
        Displayed data is NOT corrected. Limit lines are
        corrected for transducer factors, attenuation,
        and preamp gain. Limit lines appear for PEAK
        traces and for one range only.

           SELECT RANGE TO CHECK.
             All ranges (coupled)
             Range  1 :  .01  -  .15  MHz
          -> Range  2 :  .15  -  30  MHz


SCROLL WITH KNOB. SELECT FUNCTION DESIRED.

  RETURN          |SELECT          |              |              |
                  |                |              |              |PLOT
```

Figure 16. PRE-VIEW Selection Screen for VDE Conducted Test

- From the TOP LEVEL MENU, press **MEASURE**
- Select the PRE-VIEW function
- Select transducer range of interest (see Figure 16)
- Connect the RF preselector output to the spectrum analyzer input
- Connect the input cable to the appropriate preselector input

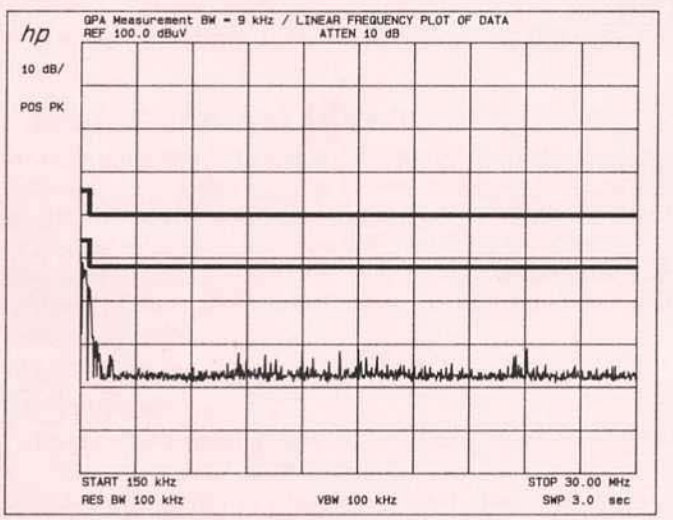


Figure 17. Spectrum Analyzer Display for Preview Mode Showing Limit Lines

TESTING FOR OVERLOAD

The RF preselector 3 dB LIN push button is used to check for overload. While in the preview mode, press the 3 dB switch and observe the amplitude level of the signals on the spectrum analyzer display. There should be a less-than-1-dB change in the observed peak levels of signals that are at least 10 dB above the noise floor. If a change in amplitude does occur, then increase the preselector input attenuation by 10 dB and repeat the 3 dB test. Continue to add attenuation until the signals behave linearly. Use the least amount of attenuation necessary to cause linear signal amplitude change. Enter this attenuator setting into the test setup table of the EMI Measurement Software before making the measurements.

CALIBRATING THE RECEIVER

The receiver can be calibrated while in the preview mode. The spectrum analyzer/EMI receiver can be placed in local operation by pressing the [LOCAL] softkey. The appropriate front-panel settings are made by the software when PRE-VIEW was selected. To calibrate the system, connect the preselector comb-generator output to the correct preselector input (lighted LED), and press the CAL SEQ key on the preselector front panel. See Section II of this application note for more information on calibrating the test receiver.

MAKING A PEAK MEASUREMENT

After the test setup has been completed and the measurement range has been previewed, the next step is to perform the actual measurement. This is accomplished by simply pressing [MEASURE] (press twice if starting from the TOP LEVEL menu). The test record will now be drawn on the computer display and the measuring receiver initialized. The computer will beep and prompt the operator to connect the transducer (a LISN) to the correct preselector input, and to press [CONTINUE]. The measurement will proceed, with data drawn on the computer display for viewing by the operator. If the data seems invalid, the test can be terminated by pressing [ABORT] at any time during the measurement. When the measurement is complete, press [CONTINUE] and the finished measurement data will be plotted on the spectrum analyzer display for viewing. The program is now at the ANALYSIS menu screen.

Saving the Measurement Data

The measurement data can be saved on your library disc for later retrieval by following these steps:

- From the ANALYSIS menu, press [DATA LIB]
- Press the [STORE] softkey
- [SELECT] the test file heading desired or press [ADD HDR] to add a new header to the library
- Type a name for your data file (i.e., test #3, device #123 — 6/8/85); press [ENTER]
- Press [RETURN]

VI POST MEASUREMENT ANALYSIS

POST-MEASUREMENT ANALYSIS FUNCTIONS

The following functions can be used to make additional tests on the peak measurement data collected.

Making a Quasi-Peak Measurement

A quasi-peak measurement using the HP85650A Quasi-Peak Adapter can be made at this time. Since the quasi-peak level of any signal is less than or equal to the peak level, quasi-peak need be done only on those signals that are close to or above the specification limit. To make a quasi-peak measurement, simply place the arrow (→) next to Quasi-Peak Measurement on the ANALYSIS menu screen and press **SELECT**. The computer will draw the measurement data on its display. At the prompt use the spectrum analyzer data knob to set the spectrum analyzer marker to the left of the area of interest. Press **CONTINUE** and set the second marker to the right of the area of interest. If the area of interest selected is large, the measurement time will be quite long. The computer will indicate the approximate measurement time and the operator can either **CONTINUE**, set **NEW MKRS**, or **ABORT** the measurement. When the quasi-peak measurement is complete, the quasi-peak trace will be shown on the spectrum analyzer display (see Figure 18.) For better viewing of the quasi-peak trace, the peak trace can be turned off by selecting the DISPLAY OPTION Peak Trace. If the **SELECT** key is pressed repeatedly, the peak trace will toggle on and off.

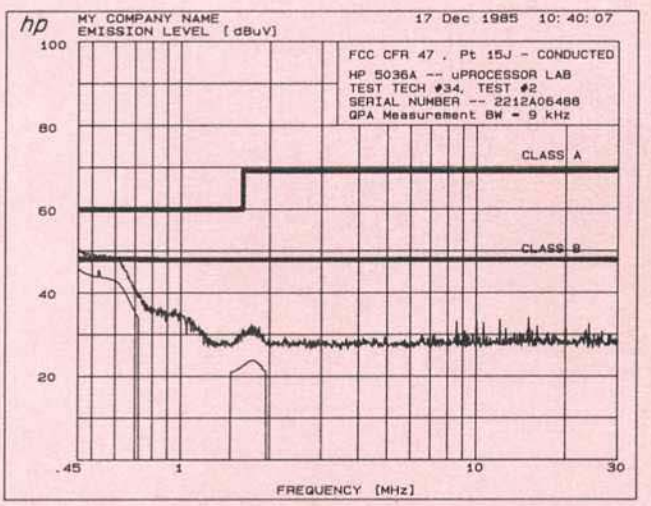


Figure 18. Spectrum Analyzer Plot of Peak and Quasi-Peak Trace

Zoom Local

Zoom Local allows the operator to take a closer look at a portion of the measurement results by narrowing the spectrum analyzer spanwidth. The spectrum analyzer is also returned to local operator control so other changes to the receiver can be made. This feature is very helpful in determining the type of signal that is being measured (i.e., narrowband or broadband).

Tune and Listen

Tune and Listen turns the analyzer into a fixed tuned receiver. The operator selects a portion of the measurement frequency range and then tunes the spectrum analyzer marker over this area to a frequency of interest (see Figure 19.) The speaker in the quasi-peak adapter provides a convenient audio output for the operator's listening.

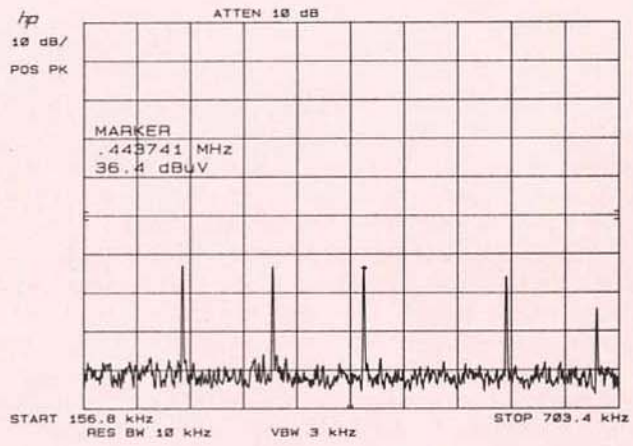


Figure 19. Spectrum Analyzer Tune and Listen Display

Mark Trace

Mark Trace allows the operator to place markers anywhere along the trace on the spectrum analyzer. Up to 15 locations can be marked using the numbers 1 through 5 as labels, and each number can be used three times. Figure 20 shows the analyzer display with markers on some signals of interest. Also shown in Figure 20 is a sample printout of marker frequencies and amplitudes obtained using the Mark Trace function.

```
Current Markers Set:

1 :      .45     MHz        50.9 dBuV
3 :      .59874  MHz        48.3 dBuV
1 :      .71724  MHz        39.6 dBuV
2 :     1.45238  MHz        27.9 dBuV
4 :     1.73984  MHz        32.4 dBuV
2 :     1.98176  MHz        28.7 dBuV
```

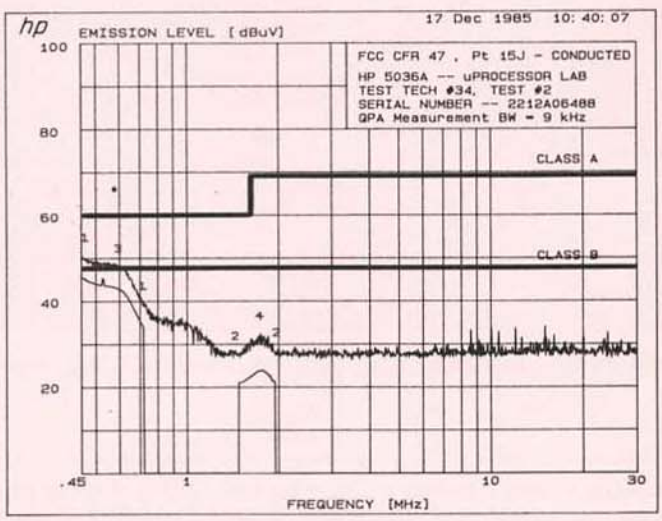


Figure 20. Mark Trace Function Display and Printout of Marker Frequencies and Amplitudes

Notes

Notes can be used to create up to 48 lines of text describing the measurement data. For example, the identification of signals that are marked by the Mark Trace function can be explained here:

Mark #1 Switching power supply harmonics @25 kHz

OUTPUTTING THE TEST RESULTS

Hard Copy Output Options

```
=============================================================
   17 Dec 1985  10:40:07
=============================================================
 3. FCC CFR 47,Part 15J WITH PRESELECTOR
    3.4  APP NOTE CONDUCTED
=============================================================
HP 5036A -- uPROCESSOR LAB
TEST TECH #34, TEST #2
SERIAL NUMBER -- 2212A06488
QPA Measurement BW = 9 kHz


PEAKS FOUND ABOVE  32 dBuV

PEAK#  FREQ (MHz)  AMPL(dBuV)
  1       .9576       36
  2       1.064       34
  3       1.745       32
  4       8.593       33
  5       10.04       33
  6       10.60       33
  7       12.02       34
  8       15.01       34
  9       16.06       32
 10       24.02       33
```

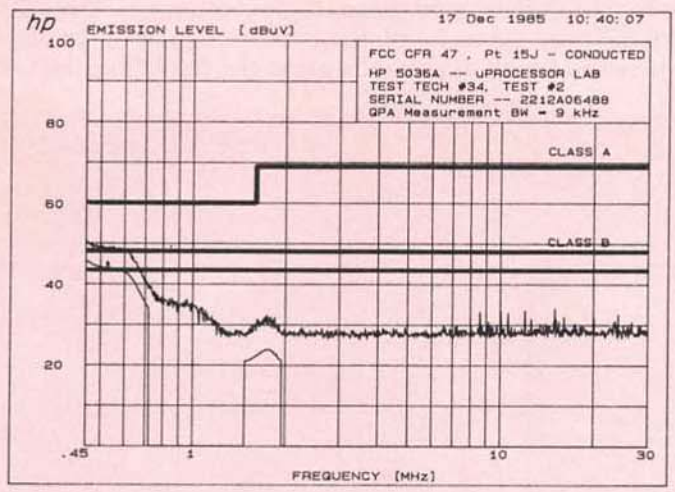


Figure 21. Print Peaks Output and Display

Print Peaks

The Print Peaks function is used to determine the amplitudes and frequencies of the peak responses of measured data (see Figure 21). The operator is asked to input a threshold in dB, and all responses which exceed this limit are found. The data can then be displayed on the controller screen or sent to the system printer. An image of the measurement data plot (as seen on the controller screen) can be sent to a graphics printer by simultaneously pressing the [SHIFT] and [GRAPHICS] keys on the controller keyboard.

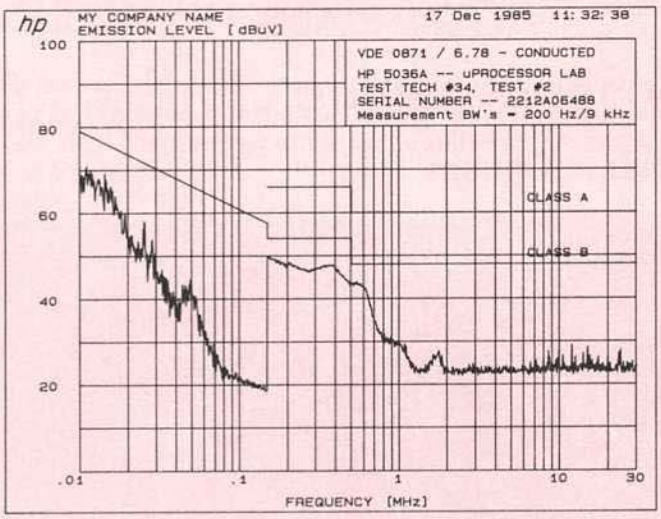


Figure 22. Typical Plot of Displayed Measurement Data

Plotting the Displayed Test Results

The PLOT function duplicates the spectrum analyzer display on a system plotter (see Figure 22.) The operator has a choice of three formats: one, two, or four plots per page. The operator selects the frame for plotting on the multiple plot formats. The PENS function makes available to eight (8) different colors for plotting different parts of the display. For example, individual colors may be chosen to draw the graticule, limit line, data, and annotation.

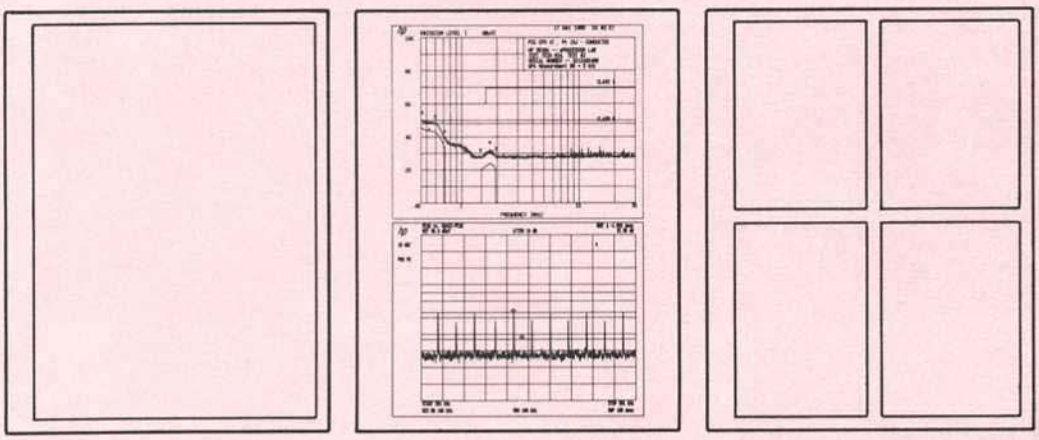


Figure 23. Examples of the Different Plot Formats Available

APPENDIX A
QUASI-PEAK DETECTION

Description of the Quasi-Peak Adapter

The HP Model 85650A Quasi-Peak Adapter is an accessory to the HP8568B RF Spectrum Analyzer and the HP 8566B Microwave Spectrum Analyzer. It provides the spectrum analyzer with the charging, discharging, and display time constants recommended in Publication 16 (1) of the Comite International Special des Pertabations Radioelectriques (CISPR) for a measuring receiver. It also makes available the three 6 dB resolution bandwidths — 200 Hz, 9 kHz, and 120 kHz — specified by CISPR 16.

Characteristics of the Quasi-Peak Receiver

Definition of terms

BWi — Impulse bandwidth
fo — Center frequency of spectrum analyzer/receiver
Fr — Pulse repetition frequency = 1/T
S — Spectral intensity of an impulse signal in rms volts/MHz
T — Time interval between pulses
Vp — Peak value of voltage transients (in volt peak) at the input to the measuring receiver
$\triangle f$ — $1/\tau$; difference between frequency fo and frequency of adjacent zero of spectrum
τ — Pulse width; $1/\triangle f$

Signal Processing

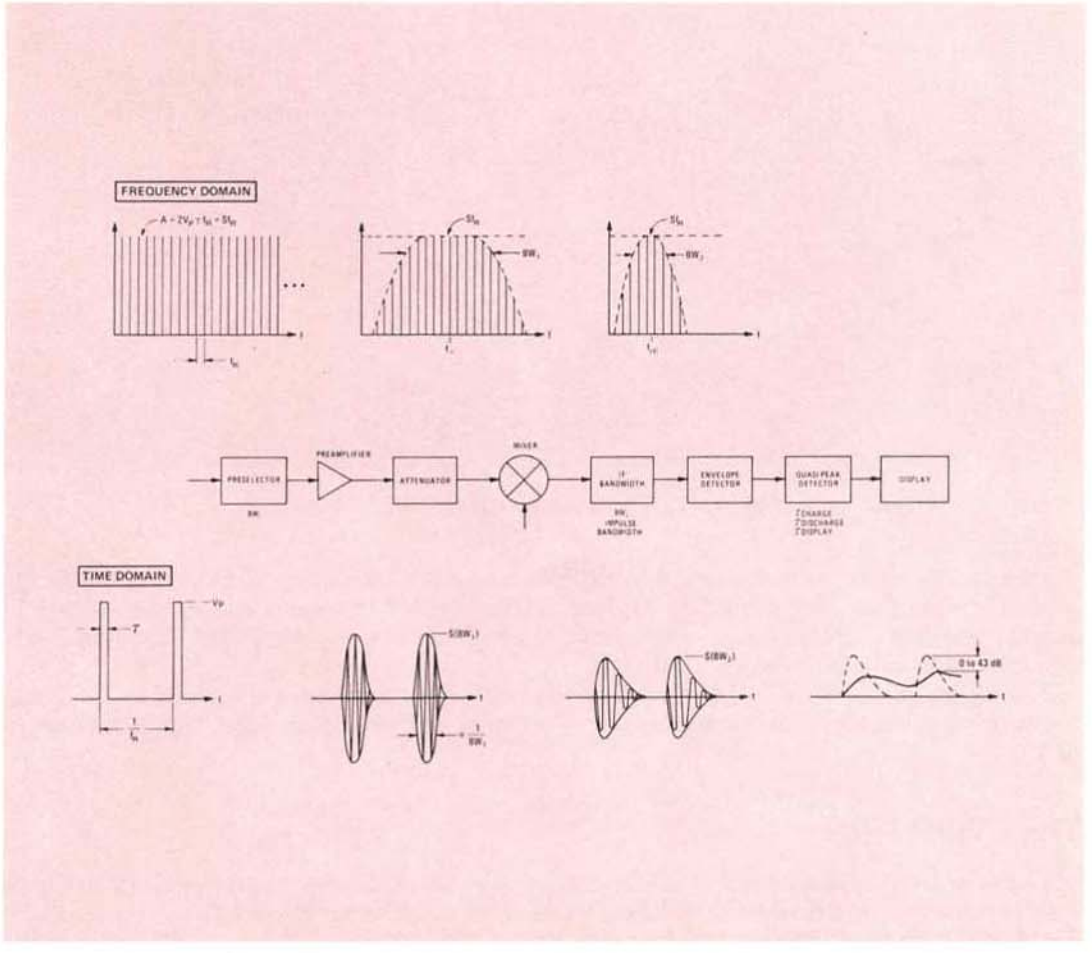


Figure A-1. Signal Processing of Broadband Signal in a Typical Quasi-Peak Receiver

An example of the signal processing of a broadband signal is shown in Figure A-1. A DC pulse of peak amplitude Vp, pulse width τ, and pulse repetition frequency Fr produces in the frequency domain a sin (X)/X distribution. Near the origin, the peak spectral intensity S will be $S = 2Vp\tau$, and each spectral component will have an amplitude of $A = 2Vp\tau Fr$. The RF preselector, in removing spectral components outside its pass band, reduces the amplitude of the time domain waveform to S(BWi) where BWi is the impulse bandwidth of the preselector. The signal continues through the preamplifier and attenuator and then through the input mixer, which converts it from RF to IF. The IF filter reduces the time domain amplitude to $S(BWi_2)$ where BWI_2 is the impulse bandwidth of the IF filter. The envelope detector, quasi-peak detector, and display complete the quasi-peak processing of the signal.

The Quasi-Peak Detector

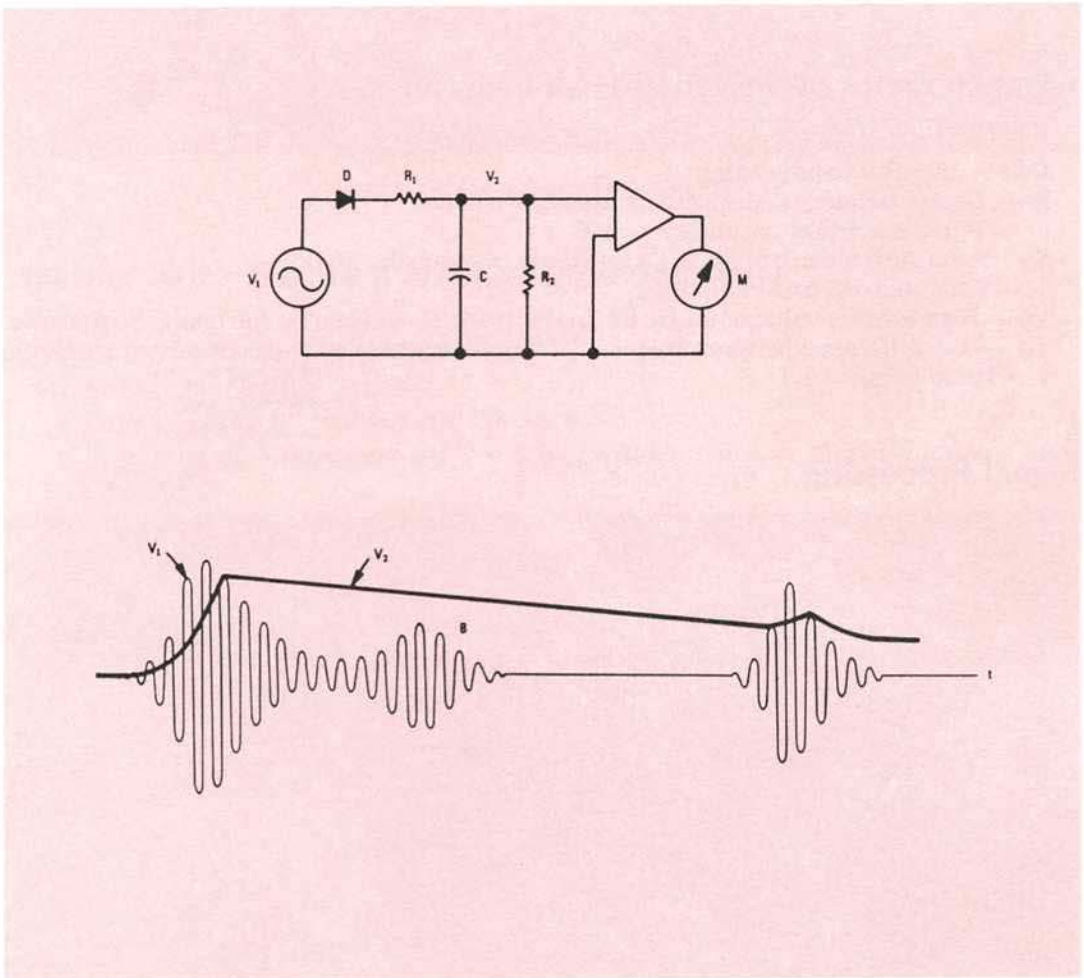


Figure A-2. Operation of a Quasi-Peak Detector

Figure A-2 shows the schematic diagram of a quasi-peak detector. The operation is as follows. The voltage V_1 is rectified by diode D. If the rectified voltage is larger than voltage V_2 across capacitor C, it will charge capacitor C through resistor R_1; otherwise, capacitor C will discharge through resistor R_2.

The charge time constant, R_1C, is less than the discharge time constant, R_2C. V_2 will therefore reach a higher value for less time between pulses (higher repetition frequencies) of V_1.

The CISPR Filters

The selectivity and shape of the IF filters in the quasi-peak adapter are specified in CISPR Publication 16. The 6 dB bandwidths of the filters are 200 Hz for Band A (10-150 kHz), 9 kHz for Band B (0.15-30 MHz), 120 kHz for Bands C/D (30-300 MHz and 300-1000 MHz, respectively).

Amplitude Characteristics of the Quasi-Peak Receiver

The quasi-peak receiver is specified by CISPR as having the same voltage response to a specified impulsive signal as to a sine-wave signal with an e.m.f. of 2 mV (66 dBμV) at all tuned frequencies. The specified impulsive signal has a pulse of MicroVolt seconds (μVs), uniform spectrum to the frequency band end (Fr), and repetition frequency (PRF). The r.m.s. value read by the measuring receiver will be 1 mV (60 dBμV) when the impedance of the source is equal to that of the receiver. Table A-1 gives the constants for each of the various bands.

Table A-1. CISPR Pulse Constants

Band	S (μVs)	Fr (MHz)	PRF (Hz)
A	13.5	0.15	25
B	0.316	30	100
C	0.044	300	100
D	0.044	1000	100

APPENDIX B

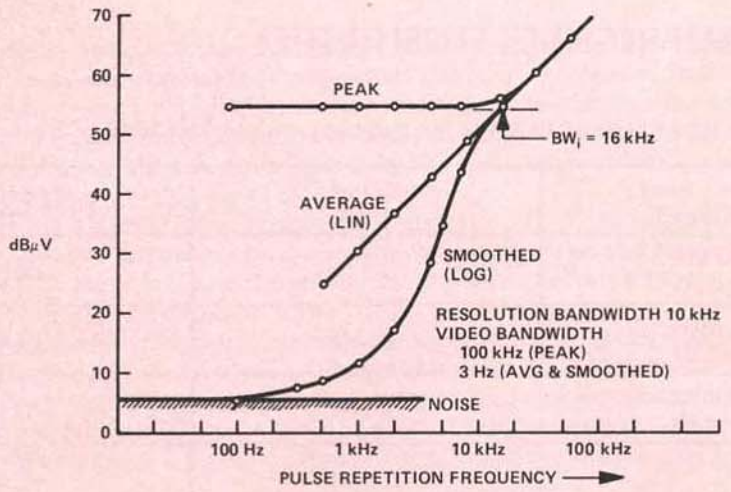
AVERAGE DETECTION

Average detection is provided in the spectrum analyzer by use of the video bandwidth filters. Video (post detection) filtering provides averaging of the higher frequency components (such as noise) at the output of the envelope detector. When the video filter bandwidth is narrower than the resolution bandwidth, averaging occurs. Narrowband (e.g., CW) signal amplitudes are not affected by video filtering.

For a true average, the video BW must be less than the lowest pulse repetition frequency (PRF), the frequency sweep must be slow enough to let the filters charge completely, and the spectrum analyzer must be in the linear amplitude display mode.

When the analyzer is in the log amplitude display mode, video filtering greatly reduces the amplitude of impulsive and random broadband signals. This is useful for measuring low-level narrowband signals in the presence of higher level impulsive signals. Since the narrowband signal will not be affected by the video filtering, it will show on the display well above the broadband signals.

For (FCC) line conducted tests, if the equipment under test exhibits emissions which exceed the limit under the above (FCC CFR47, part 15J) specified conditions, the following option may be exercised. The measurements may be made in the average mode with a 9 kHz minimum bandwidth. If the signal level in average mode is significantly less than it is in peak or quasi-mode, the emission is considered broadband and the quasi-peak value may be reduced by 13 dB for comparison to the limit[1].



With the analyzer in Linear amplitude mode, video filtering provides the average value of a signal.

In the log amplitude mode the analyzer's video filter smoothes the logarithmically distorted detector output signal. For BB impulsive signals the smoothed indication is considerably lower than the average value of the impulses. This smoothing effect allows more accurate measurement of the NB component in a mixed NB/BB spectrum. Furthermore, the measurement dynamic range is larger in log mode so that even low level NB signals in the presence of larger amplitude BB signals can be measured.

The video bandwidth needs be reduced only to the point where the rapid fluctuations of the signal are smoothed. Further reductions will not change the measured value but will increase the required settling, analysis and measurement times.

Note that the ratio of peak to average voltage for a BB impulsive signal with known PRF is the same as the ratio of the receiver impulse bandwidth to PRF: Vpeak/Vavg=BW_i/PRF. This allows for easy determination of BW_i (example above.)

Figure B-1. Post Detection Video Filtering of Impulsive Signals

[1] *FCC/OST MP-4 (1983), "FCC METHODS OF MEASUREMENT OF RADIO NOISE EMISSIONS FROM COMPUTING DEVICES," Page 7, Note 4.*

APPENDIX C
EMI RECEIVER SENSITIVITIES

TABLE OF EMI RECEIVER SENSITIVITIES

Table C-1. Typical HP 8573A/8574A Spectrum Analyzer/EMI Receiver Sensitivities

Frequency Band (CISPR Band)	*Resolution BW (6dB)*	*Average Noise (RFP/SA atten = 0 dB)*
10-150 kHz (Band A)	200 Hz	−12 dBμV
.15-1 MHz (Band B)	9 kHz	+4 dBμV
1-30 MHz (Band B)	9 kHz	−13 dBμV
30-1000 MHz (Bands C and D)	120 kHz	−1 dBμV

RFP = RF Preselector
SA = Spectrum Analyzer

APPENDIX D

MANUAL OPERATION OF THE QUASI-PEAK ADAPTER

MANUAL PEAK AND QUASI-PEAK MEASUREMENT GUIDE
Using the HP 85650A Quasi-Peak Adapter

Peak Measurement

1. Select the [START FREQ] and [STOP FREQ] settings on the spectrum analyzer (SA) for the desired frequency range of the measurement.

2. On the quasi-peak adapter (QPA), press [NORMAL] and select the desired frequency band: CISPR bandwidth of [10-150 kHz], [.15-30 MHz], or [.03-1 GHz].

3. Select the SA [RES BW], [VIDEO BW], and [SWEEP TIME] as indicated below:

Table D-1. Spectrum Analyzer Bandwidths and Sweeptimes

QPA FREQ BAND (QPA BW)	SPECTRUM ANALYZER	
	RES & VIDEO BW	SWEEP TIME
10-150 kHz (200 Hz)	3 kHz	>0.1 s/kHz
.15-30 MHz (9 kHz)	100 kHz	>0.1 s/MHz
.03-1 GHz (120 kHz)	1 MHz	>0.1 s/GHz

4. On the SA, press [SHIFT] C [AUTO] to change the reference level display units to dBuV.

NOTE:
For repeated measurements, save the above settings by pressing [SAVE] [1] on the SA. Recall the settings by pressing [RECALL] [1].

5. Individual signal peak amplitudes can be read by pressing MARKER [NORMAL] on the SA and positioning the marker on a signal.

Quasi-Peak Measurement

6. Place the SA marker on a signal peak and press [MKR→CF] to center the signal on the display.

7. Press [FREQUENCY SPAN] [0] [Hz] on the SA. Adjust sweep time if desired.

8. Press [REFERENCE LEVEL] on the SA and position the signal peak at the reference level line.

9. Press [LIN] on the SA and, if necessary, re-adjust the signal peak to within the top third of the display. (Do not allow signals to go above the top graticule line.)

10. On the QPA, press QUASI-PEAK DETECTOR [ON]. Do not make any further adjustments to the analyzer reference level. To raise the quasi-peak signal level, use the QPA [X10] POST DETECTION GAIN. If [X10] is used, 20 dB must be subtracted from the absolute amplitude reading on the SA.

11. Press [SHIFT] C [AUTO] on the SA to read the quasi-peak level in dBuV.

12. For unstable or intermittant signal levels, press TRACE B [MAX HOLD] to measure the maximum quasi-peak amplitude.

13. To measure the value of another signal frequency, press QUASI-PEAK DETECTOR [OFF] on the QPA and [RECALL] [1] on the SA. Repeat steps 6-12 of this procedure.

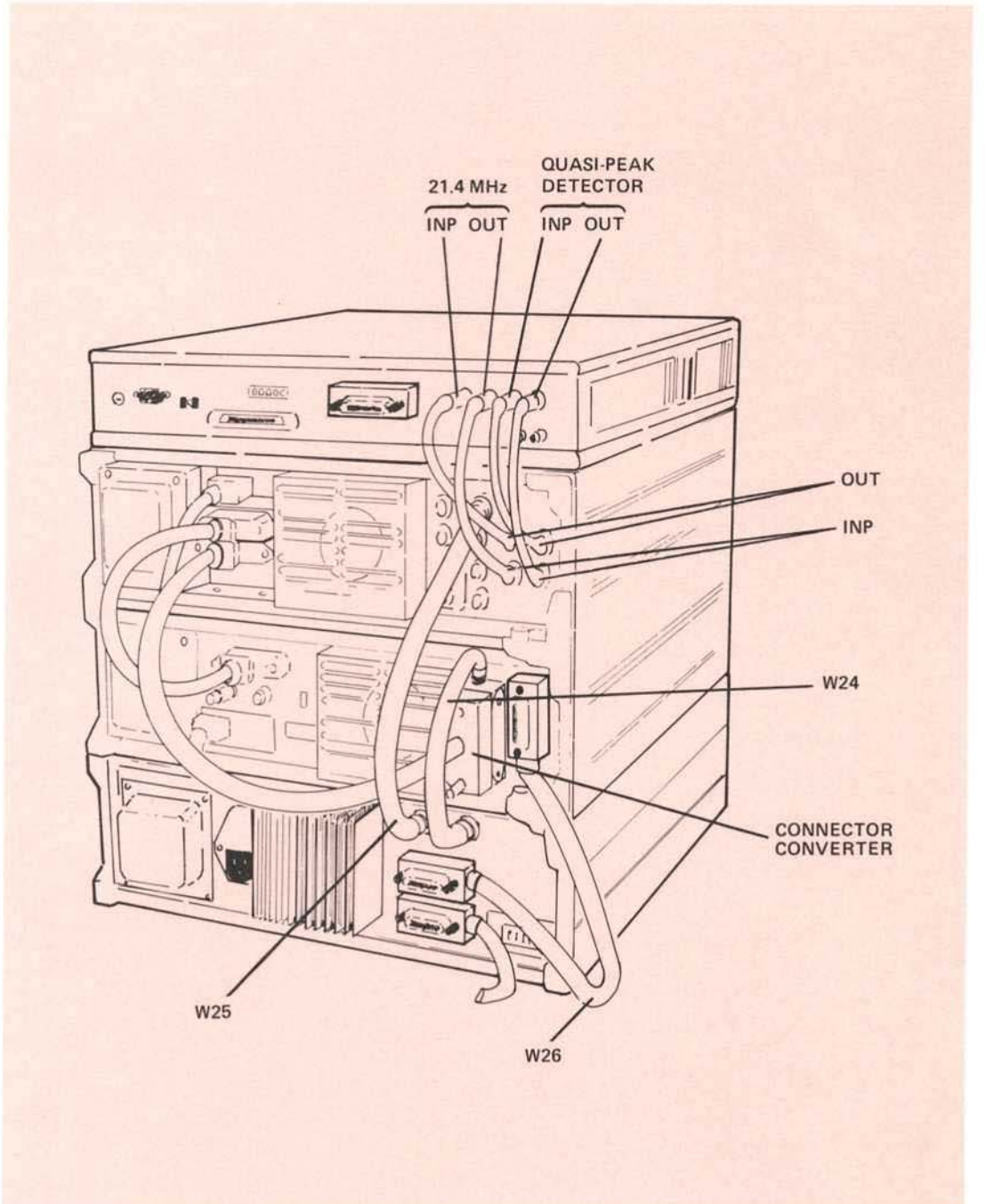
Overload of the Quasi-Peak Detector

The quasi-peak detector circuits can become overloaded (gain compressed) if the IF signal level from the spectrum analyzer is too high. To prevent an overload condition, first perform the attenuator test in the measurement section of this application note. Then, with the quasi-peak detector off, position the peak signal responses on the analyzer display at levels below the reference level line. If these conditions are met, signal peaks lower than the analyzer reference level can not produce an overload condition in the quasi-peak detector.

APPENDIX E

EMI RECEIVER REAR PANEL INTERCONNECTIONS

TYPICAL SYSTEM CONFIGURATION



For more information, call your local HP sales office listed in the telephone directory white pages. Ask for the Electronic Instruments Department. Or write to Hewlett-Packard: **U.S.A.** — P.O. Box 10301, Palo Alto, CA 94303-0890. **Europe** — P.O. Box 999, 1180 AZ Amstelveen, the Netherlands. **Canada** — 6877 Goreway Drive, Mississauga, L4V 1M8, Ontario. **Japan** — Yokogawa-Hewlett-Packard Ltd., 3-29-21, Takaido-Higashi, Suginami-ku, Tokyo 168. Elsewhere in the world, write to Hewlett-Packard Intercontinental, 3495 Deer Creek Road, Palo Alto, CA 94304.

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