

---

# User and Service Guide

Publication number 54701-97000  
Second edition, December 1993

For Safety information, Warranties, Regulatory information,  
and publishing information, see the pages at the back of this book.

© Copyright Hewlett-Packard Company 1992, 1993  
All Rights Reserved.

---

## HP 54701A 2.5-GHz Active Probe

---

## HP 54701A 2.5-GHz Active Probe

The HP 54701A 2.5-GHz Active Probe is a probe solution for high-frequency applications. This probe is designed to be powered from a connector at the front of the oscilloscope, or with the HP 1143A Probe Offset Control and Power Module. It can be used with any measuring instrument with a 50- $\Omega$  input. Following are the main features. See Chapter 3 for full specifications and characteristics.

- A bandwidth of 2.5 GHz
- Input resistance of 100 k $\Omega$
- Input capacitance of approximately 0.6 pF
- Dynamic range of  $\pm 5$  V peak ac and  $\pm 50$  Vdc
- Variable dc offset of  $\pm 50$  V
- Excellent immunity to ESD and over-voltages

### Accessories Supplied

The following accessories are supplied. See "Using probe accessories" in chapter 1 for a complete list.

- Type N(f) to BNC(m) adapter
- "Walking-stick" ground
- Box of small accessories
- Carrying case
- User and Service Guide

### Accessories Available

The following accessories can be ordered.

- Type N(m) to probe tip adapter and 50- $\Omega$  termination, HP 11880A
- BNC(m) to probe tip adapter, HP 10218A
- Type N(f) to APC 3.5(f) bulkhead adapter, HP 5081-7722 (For use with the HP 54120 family. Order with the probe as Option 001.)

The following options are available.

- ## Service Strategy

[illegible]

---

## In This Book

This book provides use and service documentation for the HP 54701A 2.5-GHz Active Probe. It is divided into three chapters.

Chapter 1 shows you how to set up and operate the probe using the power connector on the oscilloscope or the separately available HP 1143A Probe Offset Control and Power Module.

Chapter 2 gives you information about some important aspects of probing and how to get the best results with your probe.

Chapter 3 provides service information. Included is how to test the probes performance, how and when to make the one adjustment, and how to determine if your probe needs repair.

---

## Contents

### 1 Operating the Probe

- To inspect the probe 9
- Probe Operating Range 10
- To connect the probe 12
- Using the probe with oscilloscope power 14
- Using the probe with the HP 1143A power module 15
- Using probe accessories 16
- Additional Accessories 20



### 2 Probing Considerations

- Resistive Loading Effects 24
- Capacitive Loading Effects 26
- Ground Inductance Effects 28
- Probe Bandwidth 32
- Conclusion 33

### 3 Service

- General Information 38
- Performance Specifications 38
- Performance Characteristics 39
- General Characteristics 40
- Recommended Test Equipment 41
- Service Strategy 42
- To clean the instrument 43
- To return the probe to HP for service 43
- Testing Performance 44
- Testing Interval 44
- Equipment Required 44
- Test Record 44
- To test input resistance 45

## **Contents**

### Testing Performance (cont'd)

To test dc gain accuracy 46

To test bandwidth 48

### Making Adjustments 51

Equipment Required 51

Adjustment Interval 51

To adjust offset zero 52

### Troubleshooting and Repair 54

Failure Symptoms 54

To prepare the probe for exchange 56

Replaceable Parts 57

Theory of Operation 58

## **Index 61**

---

# 1

To inspect the probe 9  
Probe Operating Range 10  
To connect the probe 12  
Connecting the probe to the 54120 family oscilloscopes 13  
Using the probe with oscilloscope power 14  
Using the probe with the HP 1143A power module 15  
Using probe accessories 16  
Additional Accessories 20



---

## Operating the Probe

---

**Figure 1**

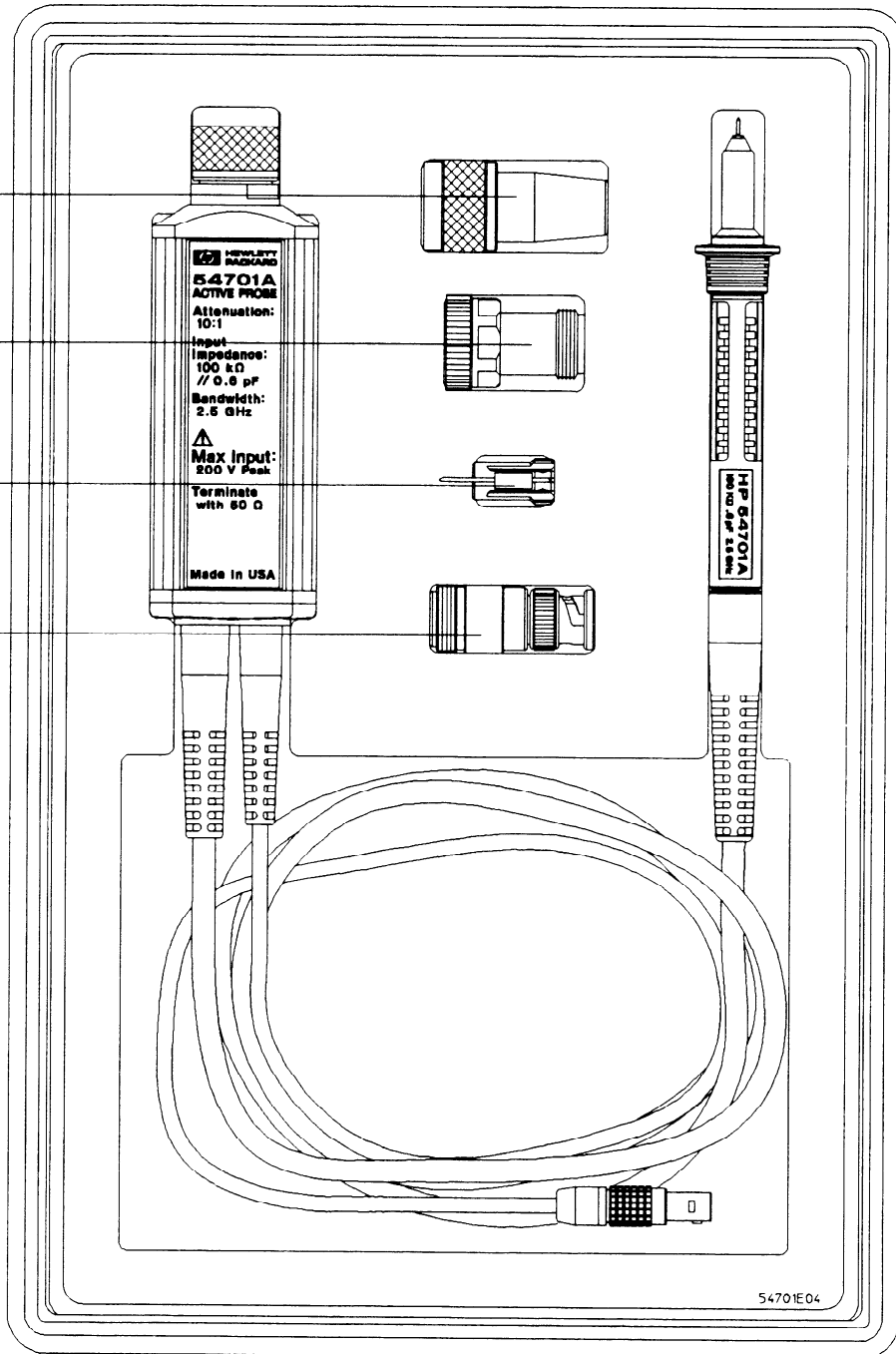
HP 11880A, Type-N(m) to  
Probe Adapter  
(not supplied, order  
separately)

HP 5081-7722, Type-N(f)  
to APC 3.5(f) Adapter  
(supplied as Option 001, or  
order separately)

Walking-stick Ground  
(supplied)

N(f) to BNC(m) Adapter  
(supplied)

Included with the probe is a  
box of small accessories.  
See page 16 for a complete  
list of accessories.



**HP 54701A Active Probe**



---

## Introduction

This chapter shows you how to connect and operate the HP 54701A Active Probe. The following information is covered in this chapter:

- Inspection
- Probe operating range
- Connecting the probe
- Operating the probe with oscilloscope power
- Operating the probe with a power module
- Using accessories

---

### To inspect the probe

- ☐ Inspect the shipping container for damage.

Keep a damaged shipping container or cushioning material until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically.

- ☐ Check the accessories.

Accessories supplied with the instrument are listed in "Accessories Supplied" in table 1, page 16 in this manual.

- If the contents are incomplete or damaged notify your HP sales office.

- ☐ Inspect the instrument.

- If there is mechanical damage or defect, or if the instrument does not operate properly or pass performance tests, notify your HP sales office.
- If the shipping container is damaged, or the cushioning materials show signs of stress, notify the carrier as well as your HP sales office. Keep the shipping materials for the carrier's inspection. The HP office will arrange for repair or replacement at Hewlett-Packard's option without waiting for claim settlement.

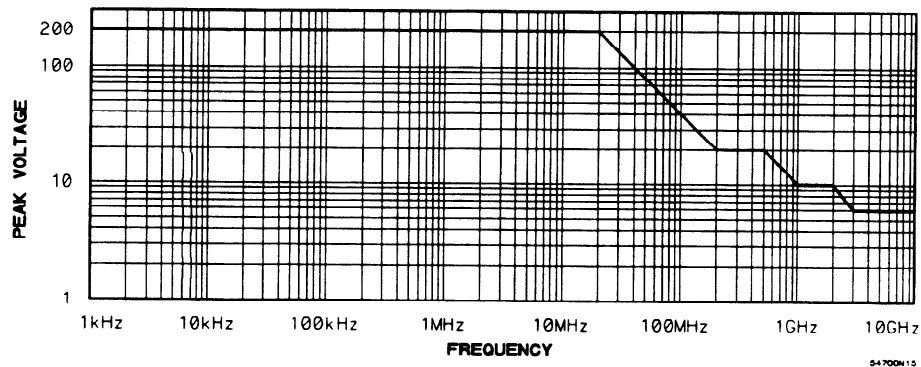
## Operating the Probe Probe Operating Range



Figure 2

### Probe Operating Range

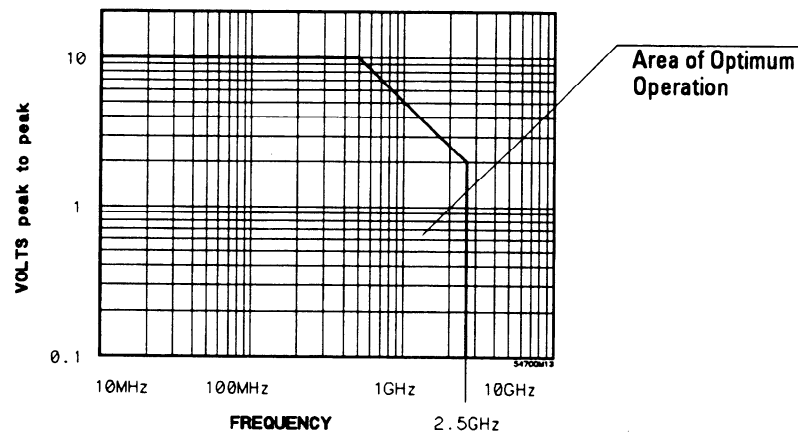
Figure 2 shows the maximum input voltage for the active probe as a function of frequency. This is the maximum input voltage that can be applied without risking damage to the probe.



### Maximum Input Voltage vs Frequency

Figure 3 shows the operating range of the probe. For the most accurate measurements and safety for the probe, signals should be within the indicated operating region.

Figure 3

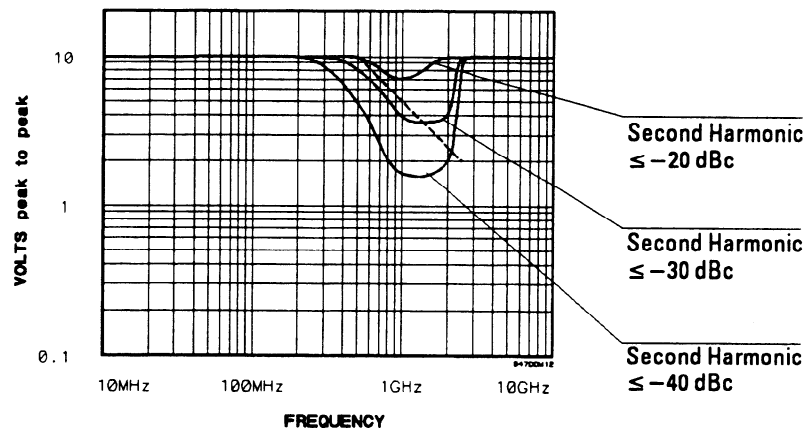


### Probe Operating Range

## Operating the Probe Probe Operating Range

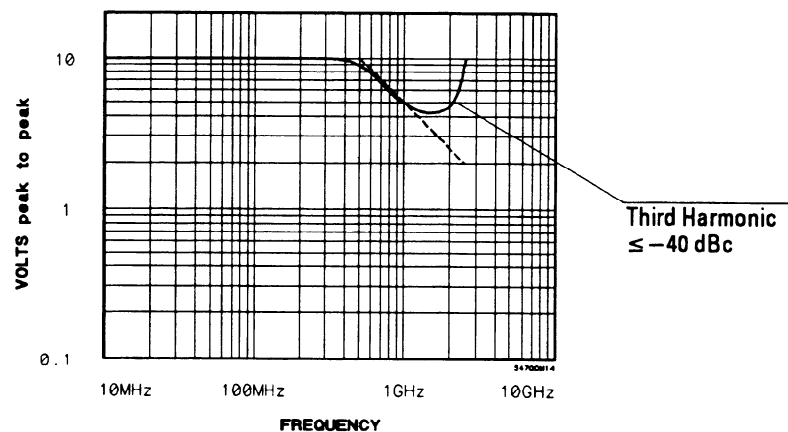
The curves in figures 4 and 5 represent the typical input signal limits for several levels of second and third harmonic distortion in the output signal. For input signals below a given curve, the level of harmonic distortion in the output is equal to or below that represented by the curve. The dashed straight line in each figure represents the operating range limit as shown in figure 3 on the previous page.

**Figure 4**



**Second Harmonic Distortion, Input Voltage vs Frequency**

**Figure 5**



**Third Harmonic Distortion, Input Voltage vs Frequency**

---

## To connect the probe

### 1 Connect the probe output to the instrument input.

The probe output is through a Type-N connector and the probe is designed to be terminated with  $50\ \Omega \pm 1\%$ .

- If your instrument has a fixed  $50\text{-}\Omega$  input, connect the probe output.
- If your instrument has selectable input resistance, connect the probe output and set the instrument input resistance to  $50\ \Omega$ . If your oscilloscope has probe power for this probe, it may automatically set the input resistance to  $50\ \Omega$  for you.
- If your instrument does not provide a  $50\text{-}\Omega$  input, connect a Type-N(f) to BNC(m) adapter and a  $50\text{-}\Omega$  feedthrough (such as an HP 10100C) to the output of the probe. Then, connect the probe to the input of your instrument.

### 2 Connect the probe power cable to a Power connector.

Red dots on the cable connector housing align with the connector keys. Align the keys when inserting the cable connector into the power connector.

---

#### CAUTION

The probe power cable connector automatically locks in the mating power connector. To separate the connectors, you must pull on the knurled part of the cable connector housing. This releases the lock. If you pull on the cable the connectors won't release and you may damage the connector or cable.

- If your oscilloscope has the appropriate probe power connector, connect the probe power cable.

Some oscilloscopes have more than one channel, or signal channels with separate trigger inputs. In these instruments, a probe power connector may be associated with a specific input. Be sure to connect the probe power cable to the correct connector so the instrument will respond correctly to the presence of the probe.

- If your instrument does not have the appropriate probe power connector, connect the probe power cable to one of the connectors on the HP 1143A Probe Offset Control and Power Module. The HP 1143A provides probe power and offset control for two probes.

**3 Calibrate the oscilloscope and probe combination with the instrument calibration routines.**

Some oscilloscopes allow you to calibrate the probe as part of the input signal path. Consult the oscilloscope User Guide for further information.

- If calibrating the probe with the HP 54700 family oscilloscope, you must calibrate the plug-in with the mainframe before calibrating the probe with the system. Use the following procedure:
  - a** Calibrate the oscilloscope using the best accuracy procedure.
  - b** Calibrate the probe with the oscilloscope using the probe calibration procedure.

When the probe has been calibrated with the HP 54700 system, the dc gain, offset zero, and offset gain will be calibrated. The degree of accuracy specified at the probe tip is dependent on the HP 54700 system specifications.

- If using an HP 1143A power module for probe power, set the Offset controls to Local and Zero while performing the calibration. Follow the calibration procedures for your oscilloscope.

---

**CAUTION**

---

An effort has been made to design this probe to take more than the average amount of physical and electrical stress. However, with an active probe, the technologies necessary to achieve high performance do not allow the probe to be unbreakable. Treat the probe with a moderate amount of care. It can be damaged if it is dropped from excessive heights onto a hard surface.

---

## Connecting the probe to the 54120 family oscilloscopes

There are a few things to consider when connecting the HP 54701A Active Probe to one of the HP 54120 family of high performance oscilloscopes.

- Use the special Type N(f) to APC 3.5(f) bulkhead adapter to connect the probe output to the input of the test set. The adapter provides the full bandwidth and pulse fidelity of the probe as well as full mechanical support. The use of other adapters can compromise signal fidelity and may be vulnerable to mechanical damage.

The Type-N(f) to APC 3.5(f) adapter can be ordered with the probe as Option 001 or ordered separately, HP part number 5081-7722.

- The dynamic range of the system will be  $\pm 3.2$  V (6.4 V<sub>p-p</sub>) which, with probe offset, covers most digital technologies.

---

## Using the probe with oscilloscope power

Probe power and offset control are provided by the oscilloscope. There are several factors to consider about the oscilloscope and probe combination.

- The oscilloscope recognizes the presence and type of probe and adapts the vertical scale factors to reflect the probe characteristics.
- The offset function is transferred to the probe but this is transparent to the user. The offset will be limited to a range acceptable to the probe. With HP 54700 family of oscilloscope plug-ins, the offset range is  $\pm 50$  V. See the sidebar below.
- Since the HP 54701A is an active probe, the bandwidth of the oscilloscope and probe combination is a mathematical combination of their individual specifications.

### Equation 1

$$\text{System Bandwidth} = \frac{0.35}{\sqrt{(t_{r1})^2 + (t_{r2})^2}},$$

where

$t_{r1}$  is the risetime of the oscilloscope.

$t_{r2}$  is the risetime of the probe.

If you are using a 54700 family oscilloscope, the resultant bandwidth with a specific mainframe, plug-in, and probe combination is noted on a sticker on the side panel of the plug-in.

The probe has limiting designed to avoid excessive power dissipation. The input operating range of the probe is  $\pm 5$  V. If the input and offset exceeds  $+14$  V relative to the probe tip, the output of the probe will limit at  $+1.4$  V. As the input plus offset reaches  $-14$  V, the output will limit at  $-1.4$  V; then, it will fold back to approximately  $-0.8$  V as the input plus offset exceeds  $-14$  V. The output of the probe will remain at the limit voltage until the input plus offset falls below approximately  $-8$  Vdc.

---

## Using the probe with the HP 1143A power module

Probe power and offset control is provided by the HP 1143A Probe Offset Control and Power Module.

- 1 Set up the power module by following the instructions in the User and Service Guide.
- 2 Connect the probe using "To connect the probe" on page 12 of this guide.
- 3 Turn on the power for the power module.
- 4 Set the appropriate Remote/Local switch.
  - To control offset voltage with the power module, set the switch to Local.
  - To control the offset voltage remotely, set the switch to Remote.
- 5 With Local control, set the appropriate Zero/Variable switch.
  - To enable the local offset control, set the switch to Variable.
  - To disable the local offset control, set the switch to Zero.
- 6 Connect the probe to the signal to be measured.

If the oscilloscope has an offset feature, be sure that it is set to zero so that the probe offset does not have to compensate for the oscilloscope offset.
- 7 If necessary, adjust the Coarse and Fine offset controls so the desired part of the signal is displayed on the oscilloscope. See sidebar below.

The offset range is greater than  $\pm 50$  V relative to the probe tip.

Bandwidth issues are the same as covered on the previous page.

The probe has limiting designed to avoid excessive power dissipation. The input operating range of the probe is  $\pm 5$  V. If the input and offset exceeds +14 V relative to the probe tip, the output of the probe will limit at +1.4 V. As the input plus offset reaches -14 V the output will limit at -1.4 V; then, it will fold back to approximately -0.8V as the input plus offset exceeds -14 V. The output of the probe will remain at the limit voltage until the input plus offset falls below approximately -8 Vdc.

### See Also

The *User and Service Guide* for the HP 1143A Probe Offset Control and Power Module about remote probe operation.

Operating the Probe  
Using probe accessories

Using probe accessories

The following figure and table illustrate the accessories supplied with the HP 54701A Active Probe.

Figure 6

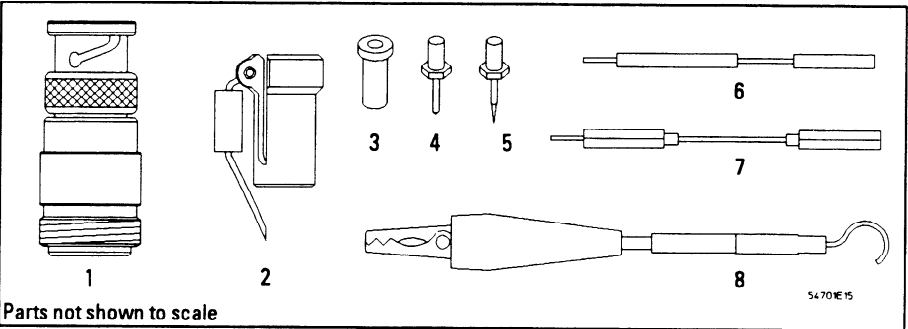


Table 1

Accessories Supplied

Item	Description	Qty	Part Number
1	Type-N(f) to BNC(m) adapter	1	1250-0077
2	Walking-stick ground	1	5960-2491
3	Single contact socket	5	1251-5185
4	Standard probe pin	5	54701-26101
5	Sharp probe pin	2	5081-7734
	Nut Driver 3/32-in (not shown)	1	8710-1806
6	200-Ω signal lead	1	54701-81301
7	Ground extention lead	1	01650-82103
8	Alligator ground lead	1	01123-61302
*	Flexible Probe Adapter	1	54701-63201
*	Probe Socket	1	5041-9466
*	Coaxial Socket	3	1250-2428
	Operating and Service Guide	1	see title page

\* These parts are illustrated on pages 18 and 19.



### **Type-N to BNC Adapter**

The Type-N(f) to BNC(m) adapter connects the output of the probe to instruments with a BNC input. If the instrument input does not have a 50- $\Omega$  termination, use an adapter with an integral 50- $\Omega$  load or add a 50- $\Omega$  feedthrough (HP 10100C) between the adapter and instrument input.

### **Walking-stick Ground**

The walking-stick ground is the best ground for general probing. It is short, and the ground wire includes a bead for damping probe resonance. This provides a well maintained probe response for frequencies to 2.5 GHz.

### **Single Contact Socket**

The single contact sockets can be soldered into a circuit to provide a probe point to hold the probe tip or ground. The socket accepts 0.018-inch to 0.040-inch pins. The sockets accept the probe tips, the walking-stick ground, the 200- $\Omega$  signal lead, and the ground extension lead.

### **Probe Pins**

There are two types of replaceable probe pins furnished with the probe. The 0.030-inch round standard probe pin is for general applications. It is made of a material that will generally bend before breaking. The 0.025-inch round sharp probe pin has a narrower point and is a harder material. It can be used to probe constricted areas or penetrate hard coatings.

---

**CAUTION**

---

Do not solder the probe tip into circuitry. Excessive heat may damage the tip or circuitry inside the probe. If you need to solder something into your circuitry, use the single contact sockets, ground extension lead, or 200- $\Omega$  signal lead. They are less easily damaged and less expensive to replace.

- To remove and replace probe pins, use the nut driver to unscrew the tip from the end of the probe.
- Be sure to screw the replacement tip all the way in or the probe may be intermittent or appear ac coupled.

### **Nut Driver**

The 3/32-in nut driver is provided for easier replacement of the probe tips.

## Operating the Probe

### Using probe accessories

#### 200- $\Omega$ Signal Lead

This 2-inch orange extension lead includes a molded-in resistor to dampen resonance caused by the lead inductance. Use this lead and the ground extension lead to provide a flexible connection to the circuit under test.

There is a tradeoff when using the extension leads. To maintain a clean pulse response, the probing system bandwidth is limited to 1.5 GHz. Probe resonance is damped by the walking-stick bead and the resistor in the signal lead.

#### Ground Extension Lead

This 2.25-inch black ground lead can be used to extend ground from the walking-stick to the circuit under test. When used with the walking-stick ground the probe resonance is damped by the bead on the walking-stick.

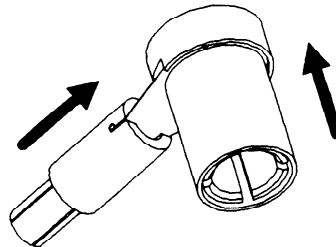
#### Alligator Ground Lead

The alligator ground lead can be used in general applications when the bandwidth of the signal is 350 MHz or lower. With no signal lead extension the probe resonant frequency is about 650 MHz.

#### Flexible Probe Adapter

The flexible probe adapter provides a high-quality connection between a coaxial socket and the HP 54701A probe. The right-angle connection allows the probe to remain parallel to a PC board and the flexibility prevents the leverage of the probe and cable from damaging PC board circuitry.

As with any cable-type interconnection, always apply insertion and removal forces to the connectors directly, and not through the cable itself (see the illustration).

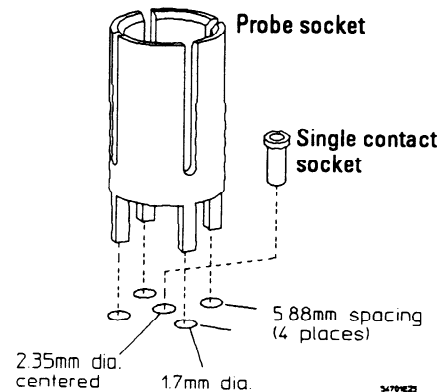


54701E27

## Operating the Probe Using probe accessories

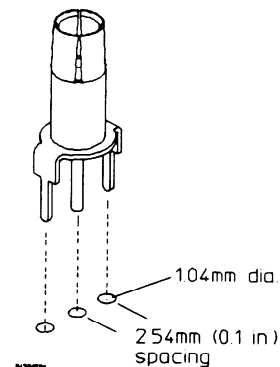
### Probe Socket

The probe socket is a direct fit to the shield surface of the HP 54701A probe. Use this socket and the single contact socket to design the highest quality probing of a PC board. The illustration shows the socket and the PC board layout needed to mount the parts.



### Coaxial Socket

The coaxial socket is designed to fit the standard HP mini-probe. When used with the flexible probe adapter, it can be installed in a circuit so you can probe with the HP 54701A. The illustration shows the socket and the PC board layout needed to mount the socket to the board.



### See Also

Chapter 2, "Probing Considerations," for a more complete discussion about the effects of probe connection techniques on signal fidelity.

### See Also

"Replaceable Parts" chapter 3 for replacement parts that are available but not listed here.

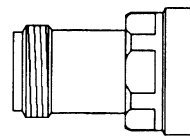
---

## Additional Accessories

The following accessories enhance use of the active probe. For ordering information, see "Replaceable Parts" in chapter 3.

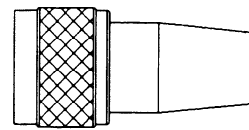
### Type-N to APC 3.5 Adapter

The Type-N(f) to APC 3.5(f) bulkhead adapter is an optional adapter (Option 001, HP part no. 5081-7722) specifically designed to connect the active probe to the input of the HP 54120 family of high-performance oscilloscopes. The adapter provides the full bandwidth and pulse fidelity of the probe as well as full mechanical support. The use of other adapters can compromise signal fidelity and may be vulnerable to mechanical damage. This adapter can be ordered with the probe as Option 001.



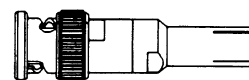
### Type-N to Probe Tip Adapter

The HP 11880A Type-N(m) to probe tip adapter is available to connect the input of the active probe to Type-N connectors. It has an internal 50- $\Omega$  load. It can be used for general testing and is specifically recommended for testing the probe bandwidth. This adapter must be ordered separately.



### BNC to Probe Tip Adapter

The HP 10218A BNC(m) to probe tip adapter is available to connect the input of the active probe to BNC type connectors. It does not have an internal load so it is not recommended for testing where the full bandwidth of the probe is needed. This adapter must be ordered separately.



Resistive Loading Effects 24  
Capacitive Loading Effects 26  
Ground Inductance Effects 28  
Probe Bandwidth 32  
Conclusion 33

---

## Probing Considerations

---

71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042 1043 1044 1045 1046 1047 1048 1049 1050 1051 1052 1053 1054 1055 1056 1057 1058 1059 1060 1061 1062 1063 1064 1065 1066 1067 1068 1069 1070 1071 1072 1073 1074 1075 1076 1077 1078 1079 1080 10

---

## Introduction

This chapter gives you some guidance about the effects of probing and how to get the best measurement results. The effect of the following parameters are covered in this chapter:

- Resistive Loading
- Capacitive Loading
- Ground Inductance
- Bandwidth

Two important issues while measuring signals with probes are how the probe/oscilloscope combination represents the signal at the probe tip and how the probe affects the circuit during the measurement.

When a probe is connected to a circuit to measure a signal it becomes part of the circuit. Probing a signal can be easy and successful if some forethought is given to the nature of the circuit under test and what type of probe best solves the measurement problem. Because of the wide variety of signals that may be encountered, ranging from high bandwidth (fast rise times) to high impedance, in a given situation one probe may do a better job than another. Therefore, it is helpful to understand the different effects caused by the interaction between the probed circuit and the probe.

---

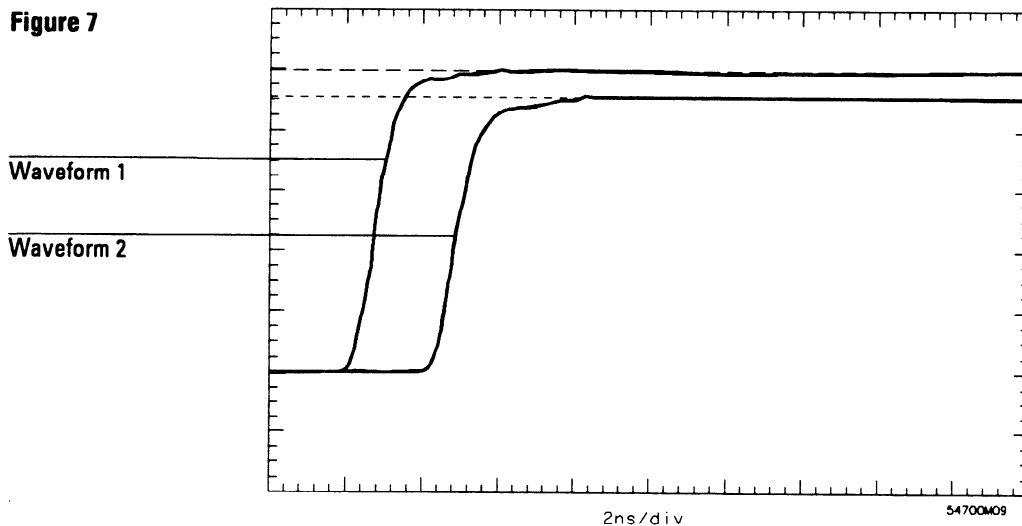
## Resistive Loading Effects

The two major effects caused by resistive loading are amplitude distortion and changes in dc bias conditions in the circuit under test.

### Amplitude Distortion

Amplitude distortion is depicted in figure 7, where waveform 1 is the signal before probing and waveform 2 is the signal while probing. (The baselines of these signals have been overlayed to show the amplitude change. If the baseline of a signal is not at zero volts it will shift when the signal is probed.)

Figure 7



### Oscilloscope Display Showing Amplitude Distortion

The cause of the error is the voltage divider developed between the source resistance of the device under test and the input resistance of the probe being used. Equation 2 calculates the error caused by the voltage divider.

### Equation 2

$$\text{Error(\%)} = \frac{R_{\text{source}}}{R_{\text{source}} + R_{\text{probe}}} \times 100$$

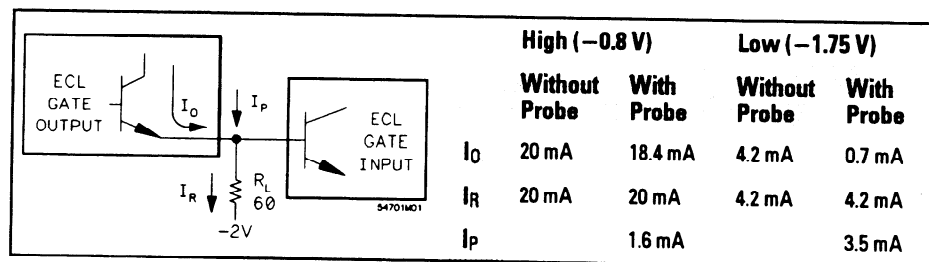
A probe with an input resistance ten times that of the source resistance of the device under test causes a 9.09% error in the measurement. It is best to use a probe with an input resistance at least ten times that of the source resistance.



### Bias Changes

Probes with low input resistance can cause bias changes in the device under test. A good example of this effect can be seen when probing ECL circuits. Figure 8 represents a typical ECL node with a  $60\text{-}\Omega$  bias resistor to  $-2\text{ V}$ .  $I_P$  represents current that flows from ground into the circuit when the probe is connected. The table shows the current that flows in each device at both the high ( $-0.8\text{ V}$ ) and low ( $-1.75\text{ V}$ ) states, with and without a  $500\text{-}\Omega$  probe connected.

Figure 8



### Probing ECL Circuits

Note that in the high state there is little difference in current flow with or without the probe connected. However, in the low state the output stage is closer to cutoff. Connecting the probe sources current into the output node, which reduces the current sourced from the gate output. The output current drops from  $4.2\text{ mA}$  to  $0.7\text{ mA}$ . The low output current can cause problems with switching noise margins. The output gate will have difficulty reaching the low threshold, so ac performance will suffer because the falling edge degrades. If a larger bias resistor had been used to keep the current levels lower, when a  $500\text{-}\Omega$  probe is attached the output gate could go into cutoff before it reaches the low threshold.

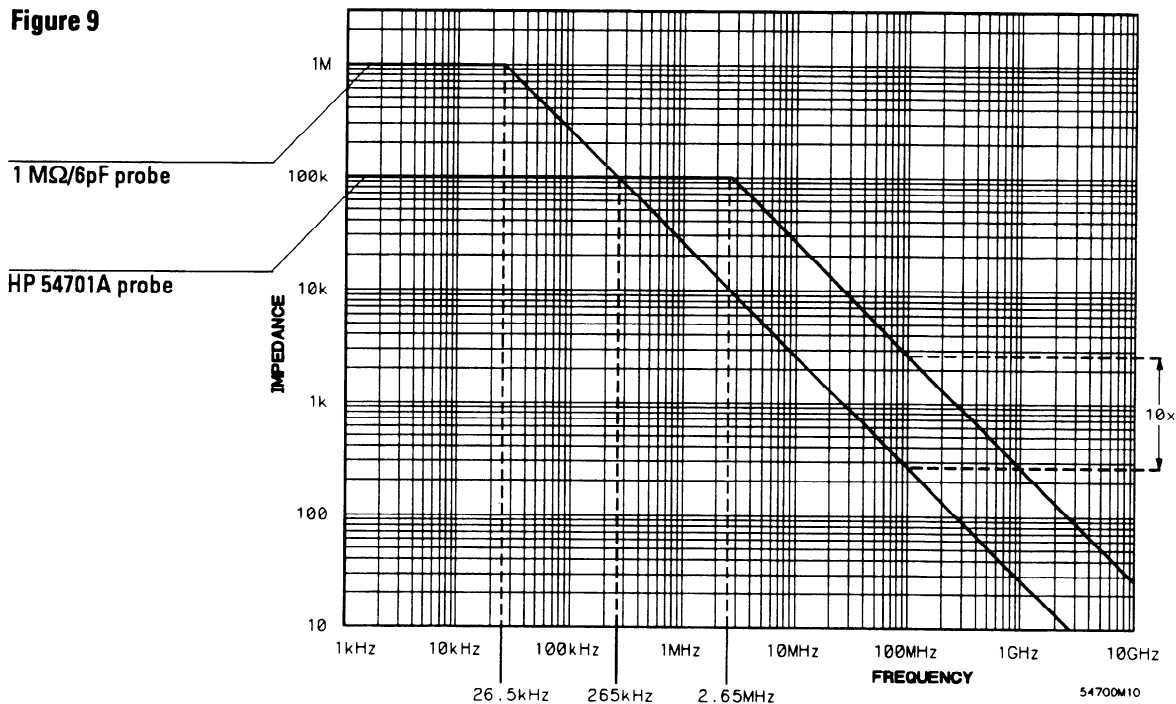
### Recommendation

Be careful not to use a probe just because it has the highest input resistance available. High-resistance probes usually come with trade-offs in other important parameters, such as higher capacitance, which also affect measurement accuracy.

## Capacitive Loading Effects

The input capacitance of a probe causes the overall input impedance to decrease as a function of frequency. For this reason, input capacitance becomes one of the most important parameters that affect high frequency measurements. Figure 9 plots the probe impedance vs frequency for two probes: a 1-M $\Omega$ , 6-pF probe and the HP 54701A probe (100 k $\Omega$ , 0.6 pF). It shows that because of the lower input capacitance, the HP 54701A probe actually has a higher input impedance for frequencies above 240 kHz. At frequencies above 2.65 MHz, it has as much as 10 times the impedance of the 1-M $\Omega$  probe.

Figure 9

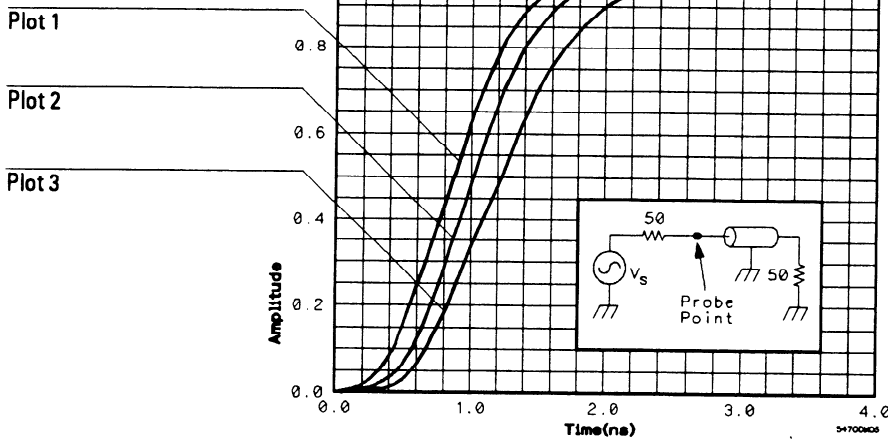


### Probe Impedance vs Frequency

The input capacitance of a probe forms an RC time constant with the parallel combination of source impedance and probe input resistance. This can cause an increase in the circuit rise time and a time delay in a pulse edge.

Figure 10 represents plots from three spice simulations showing this loading effect. Plot 1 shows the signal edge before probing. Plot 2 shows the edge after probing with a 6-pF probe and plot 3 after probing with a 15-pF probe.

**Figure 10**



#### Spice Simulation Of Probe Capacitance Loading Effects

Table 2 summarizes the data. It shows that the 6-pF probe didn't significantly increase the rise time of the signal, but delayed it (referenced at the 50% point) approximately 150 ps. The 15-pF probe not only slowed the rise time approximately 33% but also delayed the edge 340 ps.

**Table 2**

#### Probe Capacitance Loading Effects

Plot	Risetime	Delay
1	1 ns	0.0 ps
2	1.067 ns	150 ps
3	1.33 ns	340 ps

The circuit used in the simulation is modeled after a 50-Ω system with a 1-ns source and terminated transmission line with 500-ps delay. The inset shows the spice model, with the probe point where the probe was connected. As signals achieve faster rise times, probes with lower input capacitance are required to make accurate timing and rise time measurements.

---

## Ground Inductance Effects

Probe grounding techniques are an important factor in making accurate high frequency measurements. The main limitation, probe resonance, is a function of the input capacitance of the probe and the inductance of the ground return. These two parameters in series form an LC resonant circuit that, when connected to the circuit under test, becomes part of the circuit's response.

The probe resonance can cause overshoot and ringing on pulse edges that contain energy in the same frequency band as the resonance. The true response is masked, the false response gets transferred to the oscilloscope, and the oscilloscope display shows an incorrect result. If overshoot and ringing added by a probe during troubleshooting changes how the circuit functions, it can produce an incorrect judgment about circuit operation.

To minimize the problem of ground ringing, use the shortest possible ground with a probe that has the lowest possible input capacitance. Equation 3 can be used to calculate the frequency where a certain probe and grounding technique resonates.

Equation 3

$$f_r = \frac{1}{2\pi\sqrt{LC}} ,$$

where

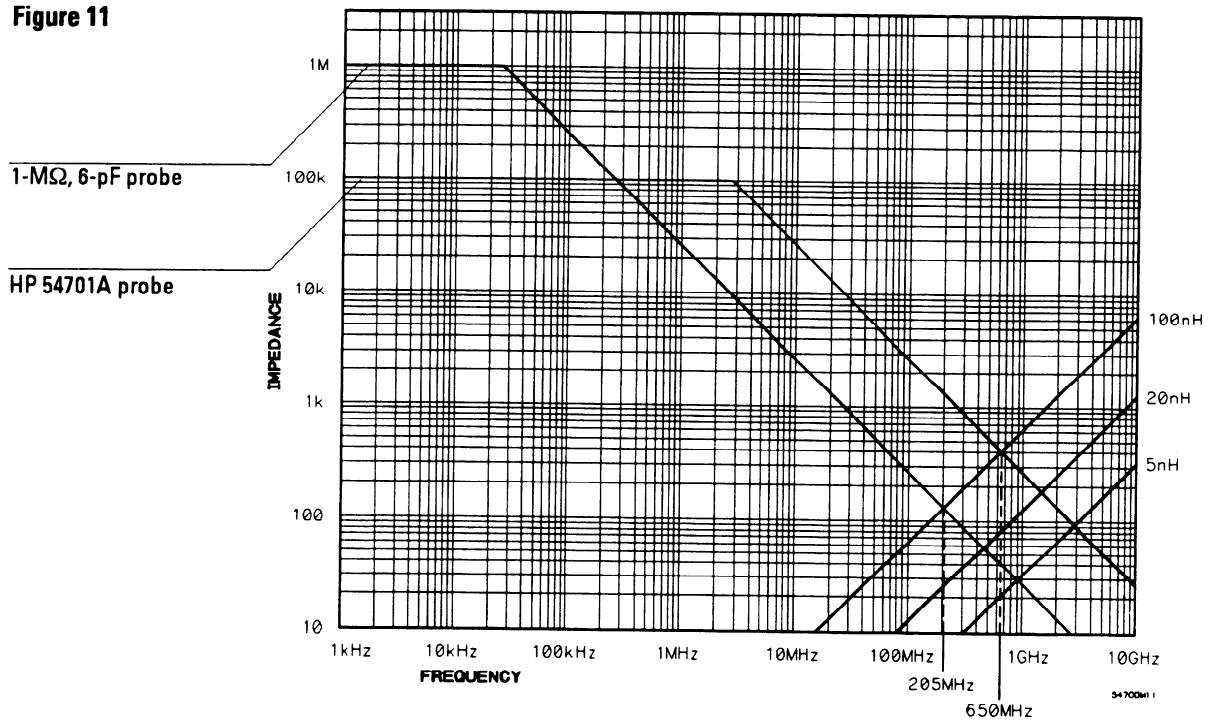
C is the probe input capacitance. (It is usually found in the probe data sheet.)

L is the inductance of the ground return. (It can be approximated using the constant of 25 nH per inch.)

Figure 11 plots the probe impedance vs frequency for two probes: a 1-M $\Omega$ , 6-pF probe and the HP 54701A probe (100 k $\Omega$ , 0.6 pF). It also plots the inductive reactance vs frequency for three different values of ground inductance. The 5-nH inductance represents a PC board socket, the 20-nH inductance a spanner ground, and the 100-nH inductance a 4-inch ground wire. Where the probe plots cross the inductance plots gives the resonant frequency of the probe and ground combination. You can see from the graphs that in all three cases the 6-pF probe resonates at approximately one-third the frequency of the HP 54701A (0.6 pF). The lower resonance means that the effect of the resonance is more likely to influence the representation of the signal.

## Probing Considerations Ground Inductance Effects

Figure 11

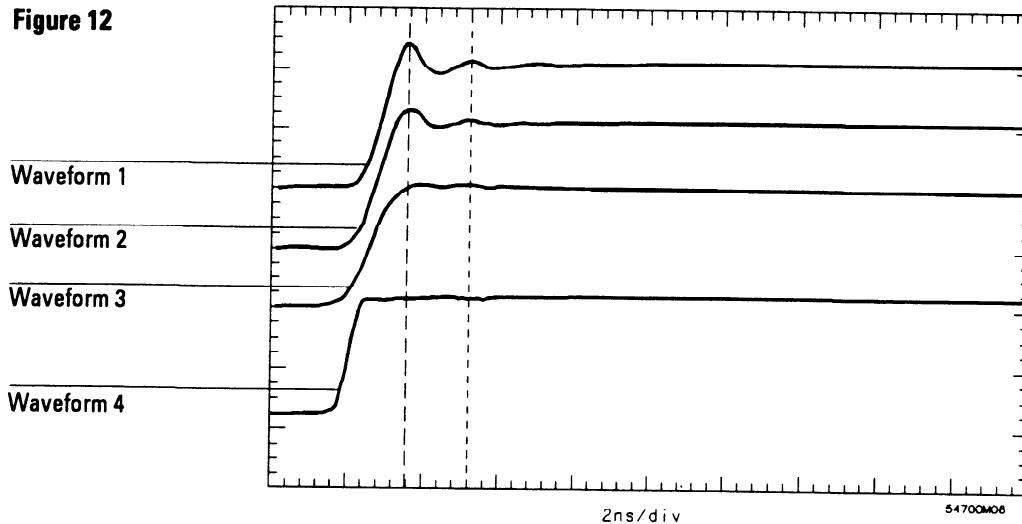


Probe Impedance and Resonance

## Probing Considerations Ground Inductance Effects

Figure 12 shows waveforms measured by the HP 54701A (100 k $\Omega$ , 0.6 pF) and the 1-M $\Omega$ , 6-pF probe; both probes are connected to a 1-GHz oscilloscope.

Figure 12



### Probe Resonance Effects

Waveform 1 shows the pulse response of a 6-pF probe measuring a 400-ps step. The ringing on the pulse is caused by the input capacitance of the probe and by the inductance of the ground return. The period of the ringing measures 1.72 ns, representing a frequency of 581 MHz. The circuit had a ground return of 1/2 inch. Using equation 3 to calculate the resonant frequency (12.5 nH and 6 pF) results in 580 MHz. The measurement and the calculation yield the same result, showing how probe resonance causes problems when probing high speed signals.

Waveform 2 shows the pulse response when the same 6-pF probe measures an 800-ps edge. Notice that the overshoot and ringing are still present, but are significantly reduced. This is because the slower signal edge has less energy at the resonant frequency of the probe.

Waveform 3 shows the pulse response when the 6-pF probe measures a 1.25-ns edge. The ringing is nearly subdued and doesn't play a significant role in the measurement.

Waveform 4 shows the HP 54701A 0.6-pF probe, with a one-inch ground lead, measuring the 400-ps edge. Because of its much lower capacitance, and even with a longer ground lead, its resonant frequency is much higher and it shows no ringing in the response.

The measurements from the first three waveforms lead to a rule of thumb:  
To minimize signal distortion due to probe resonance, provide a two-to-one, or greater, difference between the resonant frequency of the probe and the bandwidth of the signal being measured.

For pulsed data applications, the rise time of a signal can be related to the bandwidth by using a constant of 0.35 as shown in equation 4. This equation is derived from a first order RC response.

**Equation 4**

$$\text{Bandwidth} = \frac{0.35}{t_r}$$

**Example**

The 1.25-ns edge (waveform 3 in figure 12) equates to a 280-MHz bandwidth.

$$\text{Bandwidth} = \frac{0.35}{t_r} = \frac{0.35}{1.25 \times 10^{-9}} = 280 \text{ MHz}$$

This is approximately half the resonant frequency calculated for the 6-pF probe with 1/2-inch ground, 580 MHz. Therefore the subdued ringing on waveform 3 validates the rule of thumb.

As noted before, waveform 4 shows the effect when a low-capacitance probe measures a high-frequency signal. Because of the low capacitance the resonant frequency is high. Therefore, there is less chance of the probing system affecting the measurement of the signal.

---

## Probe Bandwidth

The bandwidth of the probe is often given much consideration during purchase, then forgotten while making measurements. Error in measurements occur when the frequency content (at the  $-3$  dB point) of the signal being measured approaches or exceeds the bandwidth of the probe. The probe can be modeled as a low-pass filter for the signal.

---

### Example

If a 700-MHz probe is used to measure a 1-ns signal, the rise time error can be calculated using equations 4 and 5. For this exercise assume that the oscilloscope bandwidth is great enough not to contribute any errors.

### Equation 5

$$t_r = \sqrt{(t_{r1})^2 + (t_{r2})^2} ,$$

where

$t_{r1}$  is the rise time of the probe,

$t_{r2}$  is the rise time of the signal.

- 1 Calculate the rise time of the 700-MHz probe (equation 4).

$$t_r = \frac{0.35}{\text{Bandwidth}} = \frac{0.35}{700 \text{ MHz}} = 0.5 \text{ ns}$$

- 2 Calculate the rise time of the 1-ns signal as measured by the 700-MHz probe (equation 5).

$$t_r = \sqrt{(0.5)^2 + (1.0)^2} = \sqrt{1.25} = 1.12 \text{ ns}$$

The measurement error between the actual signal and what was measured is 12%. To keep measurement errors less than 6%, use a probe with a bandwidth three or more times that of the signal.

- 3 Calculate the bandwidth of the 1-ns signal (equation 4).

$$\text{Bandwidth} = \frac{0.35}{1 \text{ ns}} = 350 \text{ MHz}$$

Use a probe with a bandwidth of 1.05 GHz (the rise time is 0.333 ns, equation 4).

- 4 Calculate the rise time of the 1-ns signal measured by the 1.05-GHz probe (equation 5).

$$t_r = \sqrt{(0.333)^2 + (1.0)^2} = \sqrt{1.11} = 1.054 \text{ ns}$$

Now, the measurement error is less than 6%.



---

## Conclusion

In conclusion we can review the issues by using the effect the HP 54701A Active Probe (100 k $\Omega$ , 0.6 pF) has while measuring a fast CMOS gate.

### Resistive Loading

Resistive loading is caused by the input resistance of the probe. When the CMOS output is high (5 V) the 100 k $\Omega$  input resistance of the probe draws 50  $\mu$ A. A CMOS gate can drive many times this current, so the load is insignificant. In addition, the output impedance of a CMOS gate is the on resistance of the output FET. Whether high or low, this is typically less than 100  $\Omega$ . The voltage divider of 100  $\Omega$  and 100 k $\Omega$  is also insignificant and will not change the value of either state of the gate.

### Capacitive Loading

CMOS gates typically have an input capacitance between 5 and 10 pF. The traces between gates will contribute another 5 to 10 pF, which gives a total of 10 to 20 pF. The 0.6-pF input capacitance of the HP 54701A probe is about 3% to 6% that of the circuit capacitance. It will not significantly change the time constant in the node being probed.

### Ground Inductance

The CMOS gate has a risetime approaching 1 ns. This equates to a bandwidth of 350 MHz (equation 4). If we use the walking-stick ground (about 20 nH) provided with the HP 54701A probe, the probe resonance will be about 1.45 GHz (equation 3). We can see that the CMOS equivalent bandwidth (350 MHz) is at less than half the resonant frequency of the probe. This fits within the rule of thumb given previously, that to avoid ringing in the response, the resonance of the probe should be at least twice the frequency of the energy in the signal.

### Bandwidth

Although it was specifically not covered in this chapter, the bandwidth of the probe and oscilloscope combination is also very important. As previously noted, with CMOS signals of 1 ns risetimes the signal bandwidth is 350 MHz. This means for an accurate representation the probe and oscilloscope combination should have at least a 3-to-1 margin in bandwidth, at least 1.05 GHz.





General Information	38
Performance Specifications	38
Performance Characteristics	39
General Characteristics	40
Recommended Test Equipment	41
Service Strategy	42
To clean the instrument	43
To return the probe to HP for service	43
Testing Performance	44
Testing Interval	44
Equipment Required	44
Test Record	44
To test input resistance	45
To test dc gain accuracy	46
To test bandwidth	48
Making Adjustments	51
Equipment Required	51
Adjustment Interval	51
To adjust offset zero	52
Troubleshooting and Repair	54
Failure Symptoms	54
To prepare the probe for exchange	56
Replaceable Parts	57
Theory of Operation	58

---

## Service

---

1877 1878 1879 1880 1881 1882 1883 1884 1885 1886 1887 1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085 2086 2087 2088 2089 2090 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 2576 2577 2578 2579 2580 2581 2582 2583 2584 2585 2586 2587 2588 2589 2590 2591 2592 2593 2594 2595 2596 2597 2598 2599 2600 2601 2602 2603 2604 2605 2606 2607 2608 2609 2610 2611 2612 2613 2614 2615 2616 2617 2618 2619 2620 2621 2622 2623 2624 2625 2626 2627 2628 2629 2630 2631 2632 2633 2634 2635 2636 2637 2638 2639 2640 2641 2642 2643 2644 2645 2646 2647 2648 2649 2650 2651 2652 2653 2654 2655 2656 2657 2658 2659 2660 2661 2662 2663 2664 2665 2666 2667 2668 2669 2670 2671 2672 2673 2674 2675 2676 2677 2678 2679 2680 2681 2682 2683 2684 2685 2686 2687 2688 2689 2690 2691 2692 2693 2694 2

---

## Introduction

This chapter provides service information for the HP 54701A Active Probe. The following sections are included in this chapter:

- Specifications and Characteristics
- Returning to HP for Service
- Testing Performance
- Making Adjustments
- Troubleshooting and Repair

---

## General Information

The following general information applies to the HP54701A 2.5 GHz Active Probe.

---

## Performance Specifications

Table 3 gives performance specifications used to test the active probe.

**Table 3**

---

### Performance Specifications

---

<b>Attenuation Factor</b>	10:1
<b>Bandwidth (-3dB)</b>	>2.5 GHz
<b>dc Gain Accuracy</b>	$\pm 0.5\%$
<b>Input Resistance</b>	100 k $\Omega$ $\pm 1\%$

## Performance Characteristics

Table 4 gives performance characteristics that are typical for the active probe.

Table 4



### Performance Characteristics

<b>Rise time*</b>	<140 ps
<b>Input Capacitance</b>	0.6 pF (typical)
<b>Maximum Input Voltage</b>	$\pm 200$ V[dc + peak ac(<20 MHz)]
<b>ESD Tolerance</b> (150 $\Omega$ /150 pF)	$\pm 12$ kV
<b>Flatness</b> <b>&lt;3 ns from rising edge</b> <b><math>\geq 3</math> ns from rising edge</b> (for input edge $\geq 170$ ps)	$\pm 6\%$ $\pm 1\%$
<b>Dynamic Range</b> (<1.5% gain compression)	$\pm 5$ V peak ac and $\pm 50$ Vdc
<b>Offset Adjustment Range</b> (referenced to the probe tip)	$\pm 50$ V
<b>Offset Accuracy</b>	$\pm 1\%$ of offset $\pm 1$ mV
<b>Offset Gain</b> (referenced to the probe tip)	11.5 V/mA
<b>RMS Output Noise</b> (dc to 2.5 GHz, input loaded by 50 $\Omega$ )	<300 $\mu$ V
<b>Propagation Delay</b>	7.5 ns (approximately)

\* Risetime figure calculated from  $t_r = 0.35/\text{Bandwidth}$

Service  
General Information

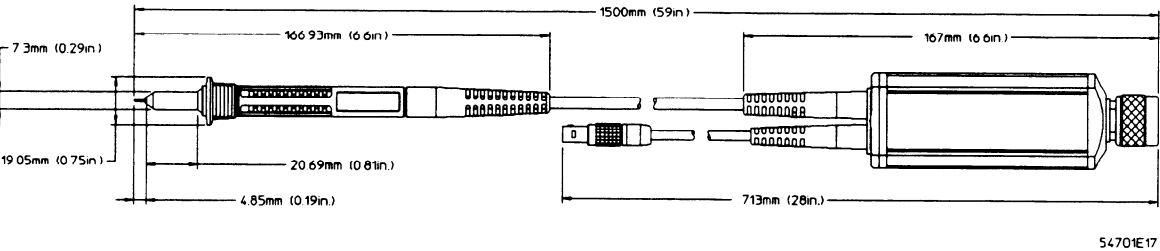
General Characteristics

The following general characteristics apply to the active probe.

Table 5

General Characteristics		
Environmental Conditions		
	Operating	Non-operating
Temperature	0 °C to +55 °C (32 °F to +131 °F)	−40 °C to +70 °C (−40 °F to +158 °F)
Humidity	up to 95% relative humidity (non-condensing) at +40 °C (+104 °F)	up to 90% relative humidity at +65 °C (+149 °F)
Altitude	up to 4,600 meters (15,000 ft)	up to 15,300 meters (50,000 ft)
Vibration	Random vibration 5 to 500 Hz, 10 minutes per axis, 0.3 grms.	Random vibration 5 to 500 Hz, 10 min. per axis, 2.41 grms. Resonant search 5 to 500 Hz swept sine, 1 octave/min. sweep rate, (0.75g), 5 min. resonant dwell at 4 resonances per axis.
Power Requirements	+17 Vdc and −17 Vdc at 110 mA each (+16.5 Vdc and −16.5 Vdc minimum respectively)	
Weight	Net: approximately 0.6 kg (1.3 lb) Shipping: approximately 1.0 kg (2.3 lb)	
Dimensions	Refer to the outline drawings below.	

Figure 13



Mechanical Dimensions



---

**Product Regulations**

**Safety** IEC 348  
UL 1244  
CSA-C22.2 No.231 (Series M-89)

**EMC** This product meets the requirement of the European Communities (EC)  
EMC Directive 89/336/EEC.

**Emissions** EN55011/CISPR 11 (ISM, Group 1, Class A equipment)  
SABS RAA Act No. 24 (1990)

Immunity	EN50082-1	Code <sup>1</sup> Notes <sup>2</sup>	
	IEC 801-2 (ESD) 4 kV CD,8kV AD	1	
	IEC 801-3 (Rad.) 3 V/m	1	
	IEC 801-4 (EFT) 1kV	1	

<sup>1</sup> Performance Codes:

- 1 PASS - Normal operation, no effect.
- 2 PASS - Temporary degradation, self recoverable.
- 3 PASS - Temporary degradation, operator intervention required.
- 4 FAIL - Not recoverable, component damage.

<sup>2</sup> Notes:  
(None)

---

**Recommended Test Equipment**

The table on the next page is a list of the test equipment required to service this instrument. The table indicates the critical specification of the test equipment and for which procedure the equipment is necessary. Equipment other than the recommended model may be used if it satisfies the critical specification listed in the table.

## Service General Information

Table 6

Recommended Test Equipment

Equipment Required	Critical Specifications	Recommended Model/Part	Use
Signal Generator	50 MHz to 2.5 GHz	HP 8663A	P
Power Meters (2) or one Dual-Channel	50 MHz to 2.5 GHz, $\pm 3\%$ accuracy	HP 436A (2), 437A (2), or HP 438A (1)	P
Power Sensor (2)	50 MHz to 2.5 GHz, 300 mW	HP 8482A	P
Power Splitter	dc to 2.5 GHz, $\leq 0.2$ dB output tracking, Type-N	HP 11667A	P
Power Supply	Power and control for probe under test	HP 1143A	P,A,T
DVM	Resistance $\pm 0.1\%$ , Volts and ohms $\pm 0.01\%$	HP 3458A	P,A,T
Power Supply	5 Vdc	HP 6114A	P
Adapter/termination	N(f)-to-probe, 50 $\Omega$	HP 11880A	P
Adapter	N(f-f), 50 $\Omega$	HP 1250-1472	P
Adapter	N(f)-to-BNC(m), 50 $\Omega$	HP 1250-0077	P,A,T
Termination	50 $\Omega$ , BNC feed-through	HP 10100C	P,A,T
Adapter	BNC (f) to banana (m)	HP 1251-2277	P

P = Performance Tests, A = Adjustments, T = Troubleshooting

## Service Strategy

The HP 54701A Active Probe is a high-frequency instrument with many critical relationships between parts. For example, the frequency response of the amplifier on the hybrid is trimmed to match the output coaxial cable. As a result, to return the probe to optimum performance requires factory repair. If the probe is under warranty, normal warranty services apply. If the probe is not under warranty, a failed probe can be exchanged for a reconditioned one at a nominal cost.

### See Also

"Troubleshooting and Repair" for further information.

---

### To clean the instrument

Use mild soap and water to clean the instrument. Harsh soaps will damage the water-based paint finish of the instrument.

---

### To return the probe to HP for service

Before shipping the instrument to Hewlett-Packard, contact your nearest HP sales office for additional details.

- 1 Write the following information on a tag and attach it to the instrument.
    - Name and address of owner
    - Instrument model number
    - Instrument serial number
    - Description of the service required or failure indications
  - 2 Remove all accessories from the instrument.

Accessories include all cables. Do not include accessories unless they are associated with the failure symptoms.
  - 3 Protect the instrument by wrapping it in plastic or heavy paper.
  - 4 Pack the instrument in foam or other shock absorbing material and place it in a strong shipping container.

You can use the original shipping materials or order materials from an HP Sales Office. If neither are available, place 3 to 4 inches of shock-absorbing material around the instrument and place it in a box that does not allow movement during shipping.
  - 5 Seal the shipping container securely.
  - 6 Mark the shipping container as FRAGILE.
- In any correspondence, refer to instrument by model number and full serial number.

---

## Testing Performance

The procedures in this section check the performance of the active probe using the Performance Specifications on page 38 as performance standards. Specifications applicable to individual tests are noted at the test for reference.

### Testing Interval

The performance test procedures may be performed for incoming inspection of the instrument and should be performed periodically thereafter to ensure and maintain peak performance. The recommended test interval is yearly or every 2,000 hours of operation. Amount of use, environmental conditions, and the user's experience concerning need for testing will contribute to verification requirements.

The calibration cycle is covered in the "Making Adjustments" section in this chapter.

### Equipment Required

A complete list of equipment required for the performance tests is in the Recommended Test Equipment table on page 41. Equipment required for individual tests is listed in the test. Any equipment satisfying the critical specifications listed may be substituted for the recommended model.

### Test Record

The results of the performance tests may be tabulated on the Test Record provided at the end of this section on page 50. The Test Record lists the performance tests and provides an area to mark test results. The results recorded in the table at incoming inspection may be used for later comparisons of the tests during periodic maintenance, troubleshooting, and after repairs or adjustments.

---

## To test input resistance

This test checks the input resistance of the active probe.

Specification:  $100\text{ k}\Omega \pm 1\%$

---

### Equipment Required

---

Equipment	Critical Specification	Recommended Model/Part
Digital Multimeter	Resistance $\pm 0.1\%$	HP 3458A

---

- 1 Connect the DMM between the probe tip and the ground shell at the front of the probe.
- 2 Set up the DMM to measure resistance.  
The resistance should read  $100\text{ k}\Omega \pm 1\text{K } \Omega$ .
- 3 Record the reading in the Performance Test Record on page 48.

#### **If the test fails**

Go to the "Troubleshooting and Repair" section in this chapter.

---

## To test dc gain accuracy

This test checks the dc gain accuracy of the probe.

Specification:  $0.1 \pm 0.5\%$

---

### Equipment Required

Equipment	Critical Specification	Recommended Model/Part
Power Supply	5 Vdc	HP 6114A
Digital Multimeter	Better than 0.1% accuracy	HP 3458A
Power Supply	Power and control for probe under test	HP 1143A
Adapter	N(f)-to-BNC(m)	HP 1250-0077
Termination	50 $\Omega$ , BNC feed-through	HP 10100C
Adapter	BNC (f) to banana (m)	HP 1251-2277

- 1 Set the power supply for  $5.0 \text{ V} \pm 0.05\%$  ( $\pm 2.50 \text{ mV}$ )  
Use the DVM to measure the voltage if necessary.
- 2 Connect the power connector of the active probe to the HP 1143A Probe Offset Control and Power Module or an oscilloscope with an appropriate probe power output.
- 3 Connect the output of the probe to the input of the DVM using the N-to-BNC adapter, 50- $\Omega$  feedthrough, and BNC-to-banana adapter.
- 4 Set the probe offset to zero.  
If using the HP 1143A power module, set the Offset controls to Local and Zero.  
If using an oscilloscope for probe power, use the channel menu to set the offset to 0.0 V.
- 5 Short the input pin of the probe to the shield at the probe tip.  
You can use the HP 11880A (see bandwidth test, page 48) which is an Type N-to-probe tip adapter with an internal 50- $\Omega$  termination. The objective is to effectively short the probe input without inducing any signal. Another method can be used if it meets that requirement.

- 6 Read and record the offset voltage on the DVM. \_\_\_\_\_mV  
If the offset voltage is greater than 1.0 mV, continue with the test but see the second sidebar at the end of this test.
- 7 Connect the probe to the 5.0 V supply.
- 8 Read and record the voltage reading on the DVM. \_\_\_\_\_mV
- 9 Subtract the reading in step 6 from the reading in step 8.  
\_\_\_\_\_mV  
The result should be 500 mV  $\pm$  2.5 mV.
- 10 Calculate the dc gain.  
$$\text{dcGain} = \frac{\text{result in step 9}}{5.00 \text{ V (supply voltage)}}$$
  
The dc gain should be between 0.09950 and 0.10050 (0.10  $\pm$  0.5%).
- 11 Record the results of step 10 in the Performance Test Record on page 50.

**If the test fails**

Go to the troubleshooting section in this chapter.

**If the offset voltage is greater than 1.0 mV**

If the offset voltage is close to the specification, it should not affect this test. Use the "Troubleshooting and Repair" section to determine why the offset voltage is not at zero.

---

## To test bandwidth

This test checks the bandwidth of the probe. A high-frequency signal generator and two power meters are used to set the input and measure the output of the probe.

Specification: down less than 3 dB, dc to 2.5 GHz

---

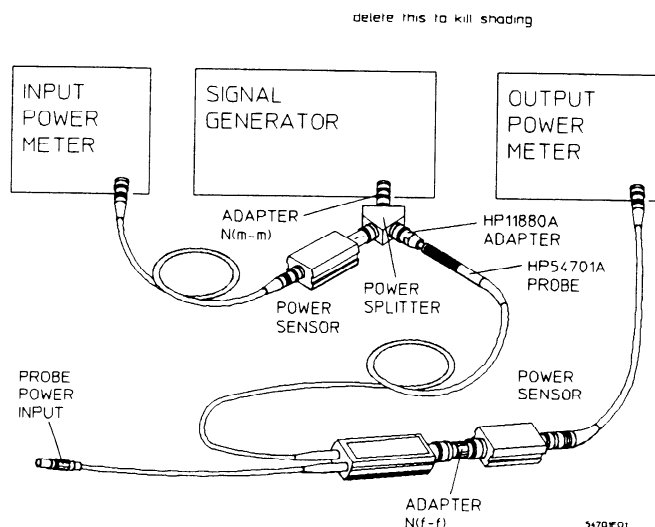
### Equipment Required

Equipment	Critical Specification	Recommended Model/Part
Signal Generator	50 MHz to 2.5 GHz	HP 8663A
Power Meters (2) or one Dual-Channel	50 MHz to 2.5 GHz,, $\pm 3\%$ accuracy	HP 436A (2), 437A (2), or HP 438A (1)
Power Sensor (2)	50 MHz to 2.5 GHz, 300 mW	HP 8482A
Power Splitter	dc to 2.5 GHz, $\leq 0.2$ dB output tracking, Type-N	HP 11667A
Power Supply	Power and control for probe under test	HP 1143A
Adapter/termination	N(m)-to-probe, 50 $\Omega$	HP 11880A
Adapter	N(f-f), 50 $\Omega$	HP 1250-0772
Adapter	N(m-m), 50 $\Omega$	HP 1250-0778

- 1 Zero and calibrate the power meters with the power sensors.
- 2 Connect the equipment as in the figure on the next page.
- 3 Connect the probe power input connector to the HP 1143A or oscilloscope probe power.
- 4 Set the probe offset to zero.  
If using an HP 1143A power module, set Offset controls to Local and Zero.  
If using an oscilloscope for probe power, use the channel menu to set the offset to 0.0 V.
- 5 Set the signal generator for 50 MHz at 0.0 dBm.
- 6 Set the power meter calibration factors to the 50 MHz value on the power sensors.



Figure 14



#### Bandwidth Test Setup

- 7 Adjust the signal generator power output for exactly  $-6.0$  dBm as read on the input power meter.
- 8 Note the power level reading on the output power meter. 50 MHz power level \_\_\_\_\_ dBm.  
The output power level will be approximately  $-26$  dBm. This corresponds to the 10:1 division ratio of the probe.
- 9 Change the signal generator frequency to 2.5 GHz.
- 10 Set the power meter calibration factors to the 2.5 GHz value on the power sensors.
- 11 Re-level the signal generator output power for a  $-6.0$  dBm reading on the input power meter.
- 12 Note the power level reading on the output power meter. 2.5 GHz power level \_\_\_\_\_ dBm
- 13 Subtract the reading in step 8 from the reading in step 12 and record the result in the Performance Test Record on page 50.  
The difference should be  $\leq 3.0$  dB


#### If the test fails

Go to the "Troubleshooting and Repair" section in this chapter.

**Service  
Testing Performance**

**Table 7**

**Performance Test Record**

 <b>HEWLETT PACKARD</b>		<b>HP 54701A Active Probe</b>
Serial No. _____		Tested by _____
Recommended Test Interval - 1 Year/2000 hours		Work Order No. _____
Recommended next testing _____		Date _____
_____		Temperature _____

Test	Limits	Results
<b>Input Resistance</b>	100 k $\Omega$ $\pm$ 1%, 99.0 k $\Omega$ to 101.0 k $\Omega$	<div style="border-bottom: 1px solid black; height: 15px; width: 100%;"></div>
<b>dc Gain Accuracy</b>	0.10 $\pm$ 0.5%, 0.09950 to 0.10050	<div style="border-bottom: 1px solid black; height: 15px; width: 100%;"></div>
<b>Bandwidth</b>	down less than 3 dB at 2.5 GHz	<div style="border-bottom: 1px solid black; height: 15px; width: 100%;"></div>

---

## Making Adjustments

This section provides an adjustment procedure for the HP 54701A Active Probe.

### **Equipment Required**

Equipment required for adjustments is listed in the Recommended Test Equipment table on page 39 of this chapter. Any equipment that satisfies the critical specification listed in the table may be substituted for the recommended model. Equipment for individual procedures is listed at the procedure.

### **Adjustment Interval**

There is no defined adjustment interval for the active probe. The adjustment is considered a factory adjustment and does not require periodic maintenance. Make adjustments only when directed by other service procedures. Defining an adjustment interval will depend on your experience.

---

## To adjust offset zero

This procedure adjusts the offset zero of the probe. Some offset in the probe can be caused by a residual offset signal from the probe's control input. Therefore, the procedure compensates for any external offset signal.

---

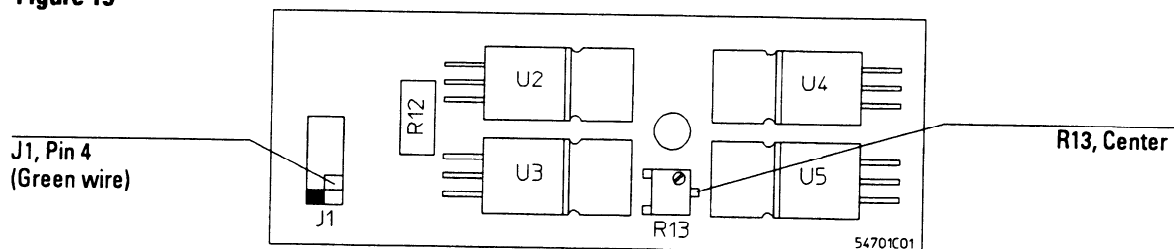
### Equipment Required

Equipment	Critical Specification	Recommended Model/Part
Power Supply	1 Vdc	HP 6114A
Digital Multimeter	Better than 0.1% accuracy	HP 3458A
Power Supply	Power and control for probe under test	HP 1143A
Adapter	N(f)-to-BNC(m)	
Termination	50 $\Omega$ , BNC feed-through	HP 10100C

- 1 With a #10 Torx screwdriver, remove the two screws at the "N" connector end of the probe power housing.
- 2 Slide the end plate aside, then slide the cover off the power housing.
- 3 To avoid damage to the cabling, temporarily refasten the end plate to the power housing.
- 4 Short the input pin of the probe to the shield at the probe tip.  
You can use the HP 11880A which is the Type N-to-probe tip adapter used in the bandwidth test. It has an internal 50- $\Omega$  termination. The objective is to effectively short the probe input without inducing any signal. Another method can be used if it provides the same result.
- 5 Terminate the output of the probe with the N-to-BNC adapter and BNC 50- $\Omega$  feedthrough.
- 6 Connect the probe power connector to the HP 1143A power module or an oscilloscope with the appropriate probe power connection.
- 7 Apply power and allow at least a 3-minute warm-up.
- 8 Set the Zero/Variable switch on the power module to Zero or set the oscilloscope vertical offset to 0.0 V.

Use the figure below to locate the appropriate measurement points in the probe power housing.

Figure 15



**Probe Power Box Adjustment Locator**

- 9 Connect the DVM to measure the voltage between ground (the "N" connector) and the center of the adjustment pot R13.
- 10 Adjust R13 for a DVM reading of  $0.0 \text{ V} \pm 25 \text{ mV}$ .
- 11 Connect the DVM to measure the voltage between ground and J1 pin 4 (green wire of the cable connector) and record the voltage reading.  
\_\_\_\_\_ mV  
This voltage is typically less than 5 mV. Measure it with  $10 \mu\text{V}$  resolution.
- 12 Multiply the reading in the previous step by  $-2.3$ . Observe the signs.  
\_\_\_\_\_ mV
- 13 Connect the DVM to measure the voltage between ground and the output of the probe at the  $50\text{-}\Omega$  feedthrough.
- 14 Adjust R13 for a reading the same as the result obtained in step 12, within  $\pm 100 \mu\text{V}$ .
- 15 Disconnect the equipment and reassemble the probe.

If the adjustment cannot be made, see the "Troubleshooting and Repair" section in this chapter.

---

## Troubleshooting and Repair

This section provides information to determine if your probe needs adjustment or repair.

- If your probe is under warranty and requires repair, returned it to HP. Contact your nearest HP Service Center.
- If the failed probe is not under warranty, you may exchange it for a reconditioned probe. See "To Prepare the Probe for Exchange" in this chapter.

---

### Failure Symptoms

The following symptoms may indicate a problem with the probe or the way it is used. Possible remedies and repair strategies are included.

The most important troubleshooting technique is to try different combinations of equipment so you can isolate the problem to a specific instrument.

#### **Probe Calibration Fails**

Probe calibration failure with an oscilloscope is usually caused by improper setup. If the calibration will not pass, check the following:

- Be sure the instrument passes calibration without the probe.
- Check that the probe passes a signal with the correct amplitude.
- If the probe is powered by the oscilloscope, check that the offset is approximately correct. The probe calibration cannot correct major failures.
- If the probe is powered by an HP 1143A power module, be sure the offset is set to Local and Zero during calibration.

#### **Incorrect Frequency Response**

Incorrect frequency response may be caused by a defective probe, plug-in or oscilloscope mainframe, or an improper application such as poor connections or grounding etc. Read chapter 2, "Probing Considerations," in this guide. If the application is correct, try the probe with another oscilloscope.

If the probe appears ac coupled at a high frequency, check for a loose probe tip.

The frequency response of the probe is determined by the amplifier hybrid in the probe and the probe cable. If the probe fails the bandwidth test, factory repair is necessary. Also read "Incorrect Pulse Response" below.

#### **Incorrect Pulse Response (flatness)**

If the probe's pulse response shows a top that is not flat (incorrect ac gain), it is most likely caused by an inaccurate 50- $\Omega$  load on the probe. The probe is designed to work into a 50- $\Omega$  load that is accurate within 1.0% ( $\pm 0.5 \Omega$ ). Check the value of the load you are using before you suspect the probe. If the load is accurate, the gain problem with the probe will have to be repaired by the factory.

If the probe appears ac coupled at a high frequency, check for a loose probe tip.

#### **Incorrect dc Gain**

The dc gain is a function of the values of internal parts. It is independent of the load on the probe. Any failure of the accuracy of the dc gain requires factory repair.

#### **Incorrect Input Resistance**

First, check that the probe tip is not loose. The input resistance is determined in the amplifier hybrid in the probe and cannot be repaired in the field. The probe must be returned to the factory for repair.

#### **Incorrect Offset**

Incorrect offset can be caused by a misadjusted offset zero (see "Offset Will Not Zero" on the next page), lack of probe calibration with the oscilloscope, or faulty offset drive current from the HP 1143A power module.

- If the probe is connected to an oscilloscope for probe power, the probe should be calibrated with the plug-in and mainframe. See "Connecting the Probe" in chapter 1 of this manual or the calibration information in your oscilloscope manual. When the probe is calibrated with an HP 54700 series oscilloscope, dc gain, offset zero, and offset errors should be calibrated to specifications as long as the probe is working.
- If the probe is connected to an HP 1143A power module for probe power, check the offset drive range of the power module (See, "To Troubleshoot

## Service Troubleshooting and Repair

the Offset Circuitry" in chapter 2 of the HP 1143A *User and Service Guide*).

### Offset Will Not Zero

With no signal input and no offset setting, the dc output of the probe should be within  $\pm 1$  mV. An error can be caused by several factors.

- If the probe is connected to an HP 54700 family oscilloscope for probe power, the oscilloscope will calibrate out an offset zero error during a probe calibration. If the offset error can not be calibrated out, the probe calibration will fail. Check the offset zero before continuing (see "To Adjust Offset Zero" in this chapter). If the probe cannot be adjusted, return it to HP for repair.
- If the probe is connected to an HP 1143A power module for probe power, lack of zero can be caused by misadjustment of the probe or a residual offset current from the power module (see "To adjust offset zero" in this chapter and "To adjust offset zero" in chapter 2 of the HP 1143A *User and Service Guide*).

---

## To prepare the probe for exchange

If your probe is out of warranty and you want to exchange your failed probe for a reconditioned probe, you need to keep the cover plate that holds the probe serial number. The reconditioned probe will not have a serial number. When you receive the reconditioned probe, put your cover plate with serial number on the reconditioned probe.

Use the following procedure to remove or replace the cover plate.

- 1 With a #10 Torx screwdriver, remove the two screws at the "N" connector end of the probe power housing.
- 2 Slide the end plate aside and slide the cover off the power housing.
- 3 To protect the cabling, use the two screws to re-fasten the end plate to the housing.
- 4 Reverse the procedure to fit your serial plate to the probe power housing of the reconditioned probe.
- 5 For return instructions, see "To return the probe to HP for service" in this chapter.

The exchange part number is listed in table 8, "Replaceable parts," page 57.



## Replaceable Parts

Except for the accessories, which includes probe tips, there are few field replaceable parts for the HP 54701A Active Probe. The replaceable parts are listed in table 8 below. Accessory part numbers are listed in table 1, page 16.

### Ordering Information

To order a part, quote the HP part number, indicate the quantity desired, and address the order to the nearest HP sales office.

### Direct Mail Order System

Within the USA, Hewlett-Packard can supply parts through a direct mail order system. There are several advantages to this system:

- Direct ordering and shipment from the HP parts center in California, USA.
- No maximum or minimum on any mail order (there is a minimum amount for parts ordered through a local HP sales office when the orders require billing and invoicing).
- Prepaid transportation (there is a small handling charge for each order).
- No invoices.

In order for Hewlett-Packard to provide these advantages, please send a check or money order with each order.

Mail order forms and specific ordering information are available through your local HP sales office. Addresses and telephone numbers are located in a separate document shipped with the manuals.

**Table 8**

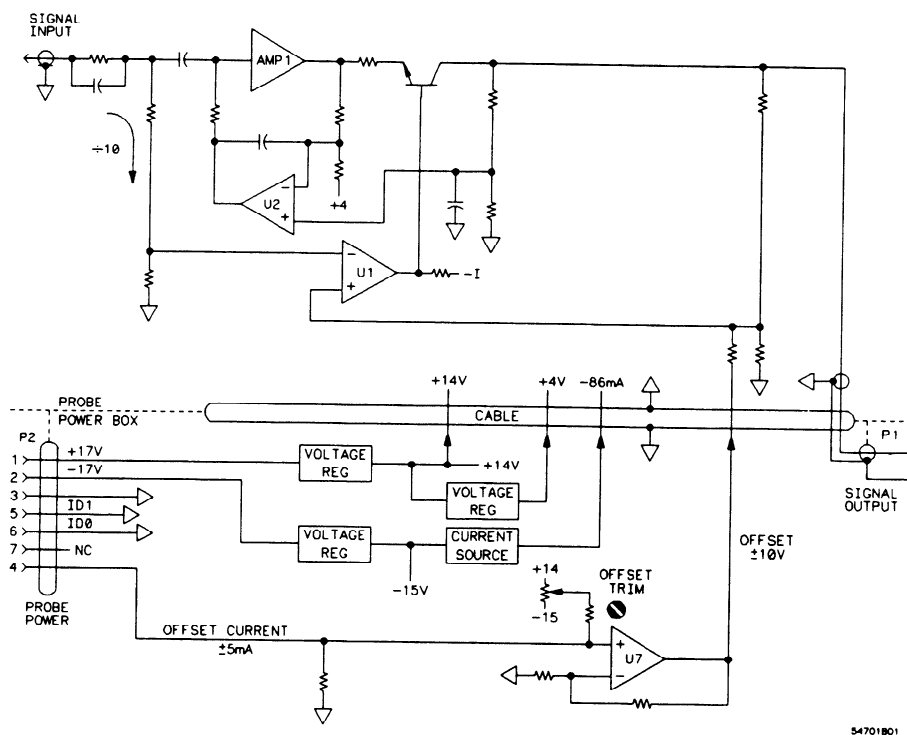
### Replaceable Parts

Ref. Des.	Description	Qty	Part Number
A1	Exchange assembly, active probe		54701-69101
MP1	Label, active probe	1	54701-94301
MP2	Label, probe power box	1	54701-94303
MP3	Probe system carrying case (without MP4 and MP5)	1	54701-45501
MP4	Foam set	1	5041-9442
MP5	Label, carrying case	1	5090-4488
MP6	Plastic parts box	1	1540-0022

## Theory of Operation

The following is a brief discussion of the basic operating principles of the HP 54701A active probe. Use the simplified circuit diagram shown below.

Figure 16



### Active Probe Simplified Circuit Diagram

#### Probe Circuitry

All of the probe circuitry is constructed on a ceramic substrate with discrete parts and two operational amplifier chips. The circuit is a two-path amplifier, one path for the high-frequency component of the signal and one for the low-frequency component.

**Input Divider** The signal is divided twice in the input impedance network. It is divided by ten and fed to the high-frequency amplifier. Another pickoff, 0.4% above ground, goes to the low-frequency amplifier.

**High-Frequency Path** The  $\div 10$  signal is ac coupled to a series of discrete emitter followers, Amp 1. Operational amplifier U2 sets the bias at the input of the emitter follower amplifier. The high-frequency signal drives the emitter of a common base amplifier. The common base amplifier drives the output cable.

**Low-Frequency Path** U1 provides the low-frequency path. One input to U1 is 4% of the signal to the high-frequency amplifier. The other input to U1 is 4% of the probe output voltage, summed with the offset voltage from the probe power box. The gain/bandwidth product of U1 limits the frequency response of the low-frequency amplifier to 400 kHz. U1 drives the base of the common base stage.

#### Power Box Circuitry

The probe signal is fed via the coaxial cable directly through the power box to the Type-N connector.

The power box takes five inputs from the probe power connector and conditions them for the probe. The probe power inputs are:

- Two probe ID lines
- Two supplies, +17 Vdc and -17 Vdc
- Offset current of  $\pm 5$  mA

The probe ID lines are pulled to ground and identify the probe when it is used with oscilloscope probe power.

The probe power box provides to the probe:

- Two voltage supplies, +14 Vdc and +4 Vdc
- A current source of -86 mA
- An offset voltage of  $\pm 10$  V

An adjustment in the offset circuitry trims any offset error when there is no offset input.



---

## Index

---

### A

accessories  
alligator ground lead, 18  
BNC to probe tip adapter, 20  
coaxial socket, 19  
flexible probe adapter, 18  
ground extension lead, 18  
nut driver, 17  
probe pins, 17  
probe socket, 19  
single contact socket, 17  
200- $\Omega$  signal lead, 18  
Type-N to APC 3.5 adapter, 20  
Type-N to BNC, 17  
Type-N to probe tip adapter, 20  
walking-stick ground, 17  
accessories available, 2  
accessories supplied, 2  
accessories, using, 16–19  
adjusting, active probe, 51  
adjustment interval, 51

### B

bandwidth  
of oscilloscope with probe, 33  
of probes, 32  
of signals, 31–32  
testing active probe, 48  
with 54700 family, 14  
with oscilloscope, 14

### C

calibration  
failure, 54  
probe with oscilloscope, 13  
capacitive loading, 33  
characteristics, 39  
cleaning, 43  
connecting power, 12  
connecting to 54120 family, 13  
connecting to oscilloscope, 12

### D

dimensions, 40  
direct mail ordering, 57

### E

errors  
amplitude distortion, 24  
bias changes, 25  
capacitive loading, 26–27  
probe resonance, 28–31  
resistive loading, 24–25  
exchanging, 56

### F

failure symptoms, 54

### G

gain accuracy, testing active probe, 46  
ground inductance, 28, 33

### H

harmonic distortion, 11

### I

input capacitance, 28  
input resistance, oscilloscope, 12  
input resistance, testing active probe, 45  
inspecting, 9

### L

limiting, probe offset, 14–15  
lock  
probe power cable, 12

### M

maximum input voltage, 10

### O

offset  
with HP 1143A power, 15  
with oscilloscope power, 14  
offset errors, 55  
offset limiting, 14–15  
offset zero  
adjusting, 52  
errors, 56  
operating environment, 40  
operating probe  
with HP 1143A power, 15  
with oscilloscope power, 14  
operating range, 10–11  
options, 3  
ordering parts, 57

### P

packing for return, 43  
parts list, 57  
performance test record, 50  
power requirements, 40  
preparing for exchange, 56  
probe ID, 59  
probe power cable lock, 12  
probes  
capacitive loading, 26–27  
capacitive loading effects, 27  
ground inductance, 28–31  
grounding, 28  
high resistance, 25  
input impedance, 26  
resistive loading, 24–25  
resonance, 28

### R

remote operation, 15  
repair, 54–59  
replacing parts, 57  
resistive loading, 33  
resonance  
of probe, 28–31  
rule of thumb, 31  
resonant frequency, 28  
returning probe to HP, 43

### S

service strategy, 3, 42  
specifications, 38  
storage environment, 40

### T

terminating probe, 12  
test equipment required, 42  
test interval, 44  
test record, 44  
testing active probe  
bandwidth, 48  
dc gain accuracy, 46  
input resistance, 45  
testing performance, 44  
theory, 58  
troubleshooting, 54–59

### W

weight, 40

---

**About this edition**

This is the second edition of the *HP 54701A 2.5-GHz Active Probe User and Service Guide*.

Publication number

54701-97000

Printed in USA.

Edition dates are as follows:

1st edition, May 1992

Second edition, Dec 1993

New editions are complete revisions of the manual.

Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by the customer. The dates on the title page change only when a new edition is published.

Many product updates and fixes do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one to one correspondence between product updates and manual updates.

The following list of pages gives the date of the current edition and of any pages changed in updates to that edition.

All pages original edition

