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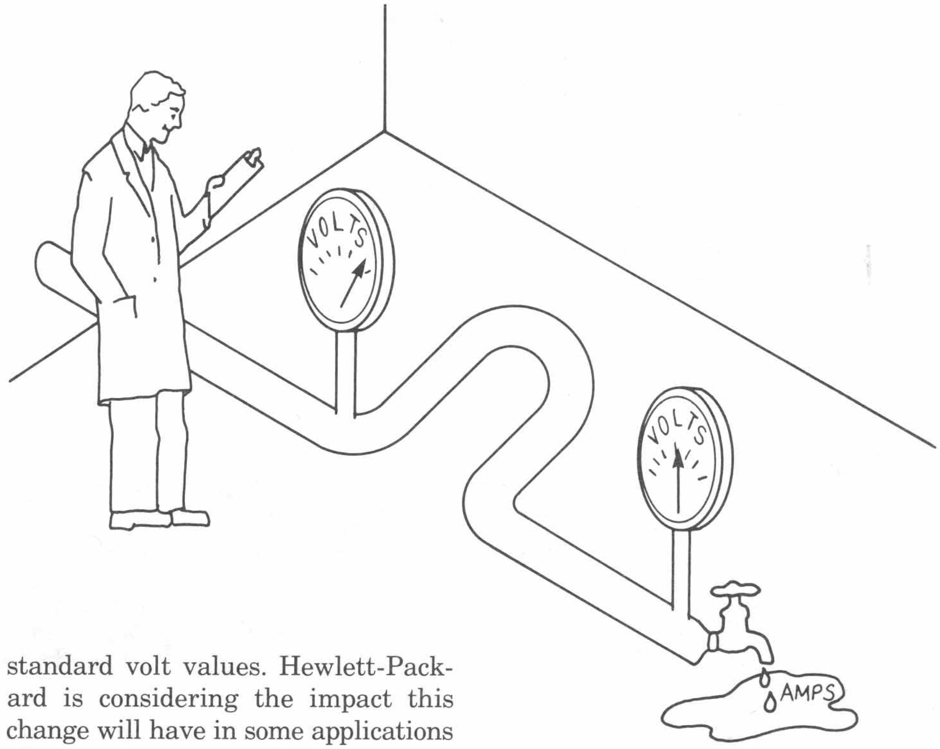
2nd Quarter 1988

The Values for the Volt and Ohm are Changing

Joe Corege
Hewlett-Packard



Volt (vōlt) *n. Abbr.* **V 1.** The International System unit of electric potential and electromotive force, equal to the difference of electric potential between two points on a conducting wire carrying a constant current of one ampere when the power dissipated between the points is one watt. **2.** A unit of electric potential and electromotive force equal to 1.00034 times the International System unit. In this sense, also called the "international volt." [After Count VOLTA.]

Are you aware? The standard volt and the ohm will be correcting to a new legal value on 1 January 1990.

There have been a few changes since the Treaty of the Meter was signed on 20 May 1875, (see Figure 1).

The change in the Josephson Junction frequency-voltage ratio 2e/h is smaller in most countries compared to the SI value set in 1972. Although the absolute value has not yet been determined, Figure 2 shows the expected value each country must adjust. This table is from the "Report on the 17th Session of the Consultative Committee on Electricity" written in the *Journal of Research* of the National Bureau of Standards.

In the U.S. the volt is expected to change by approximately −9 ppm, France by −6.5 pmm and all other countries −7.8 ppm. This means adding these values to your present standard volt values. Hewlett-Packard is considering the impact this change will have in some applications of current and future HP products, both hardware and software.

The remainder of this article is reprinted with permission from the author, Dr. David W. Braudaway of Sandia National Laboratories in Albuquerque, New Mexico. The article is from the April/May 1988 issue of the *Instrumentation and Measurement Society* newsletter and gives a history of changes since the unit began in 1884.

President's Column

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Albuquerque, New Mexico

Comments and concerns continue to be voiced on the change of the volt and ohm scheduled for 1 January 1990. There is question as to why an adjustment of the numbers by which we know the volt and ohm is needed.

A brief review of the history of these values brings the perspective that this is not the first adjustment and that, as knowledge improves in the future, we should expect the need to adjust again.

A relatively large change in the electrical unit values was made in 1948. Also changed at that time was the way the units were defined. Prior to 1948, each unit was, at least officially, defined by an artifact; the system was the International Set of Units, begun in 1884 and modified in 1893, 1908, and 1910. The ohm was defined by a 106.300 cm column of mercury with a cross section of 1 mm_2 at 0°C, the volt was provided by the standard cell, and the ampere was defined by the silver voltameter. There is a question of how often the ohm and ampere were actually realized, but because all three units were defined, ohm's law could and did have a constant of proportionality! The change of definition in 1948 was away from the individual artifacts and to a system where all the units were defined or derived from a basic set; specifically, length, mass, and time. The new units were called the absolute units or abs. for short. The value of the ohm was established by comparison to the reactance of a calculable inductor or capacitor. In turn, the values of inductance and capacitance were derived from length, mass, and time through the velocity of light, length, and the defined permeability of free space.

As might be imagined, the ability to measure had improved over the many years the international units were in existence. Improvements in fundamental measurements in the 1920s and 1930s made evident the need for a change in the unit values. This change was delayed by the deteriorating international climate, but was accomplished in 1948 along with the change to abs. units. The electrical units were subject to a large change in value; for example:

1 international ohm = 1.000495 abs. ohm

1 international volt = 1.000330 abs. volt, and

1 international farad = 0.999505 abs. farad.

In January 1969, another change was made, but this time only in the value of the volt. The official change was 11 parts per million (ppm), but in the USA the change was 8.4 ppm. This corrected the difference that had developed in the value maintained by the USA; other nations made changes of different magnitudes to correct their values. 1972 saw a change in volt definition to that established by the ac Josephson effect. In June of that year, the USA set the 2e/h ratio at 483.593420 GHz/v(NBS), which represented the volt value at NBS at that time. Internationally the value selected by the Consultative Committee on Electrically was corrected for change in the

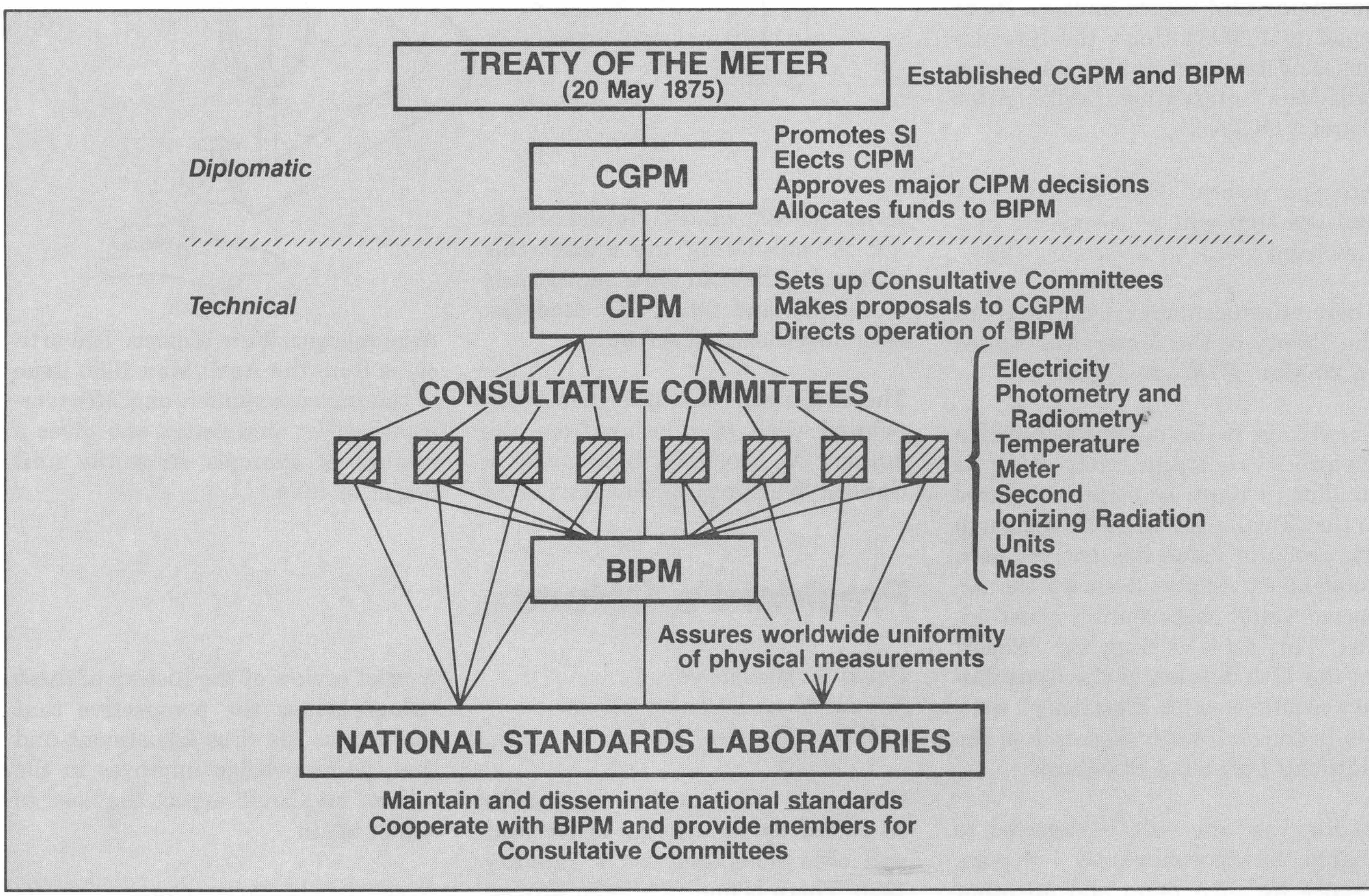

Figure 1. Schematic depiction of how basic measurement units and standards are coordinated internationally. (Treaty of the Meter: *La Convention du Metre;* CGPM: *Conference General des Poids et Mesures* or General Conference of Weights and Measures; CIPM: *Comite International des Poids et Mesures* or International Committee of Weights and Measures; BIPM: *Bureau International des Poids et Mesures* or International Bureau of Weights and Measures.)

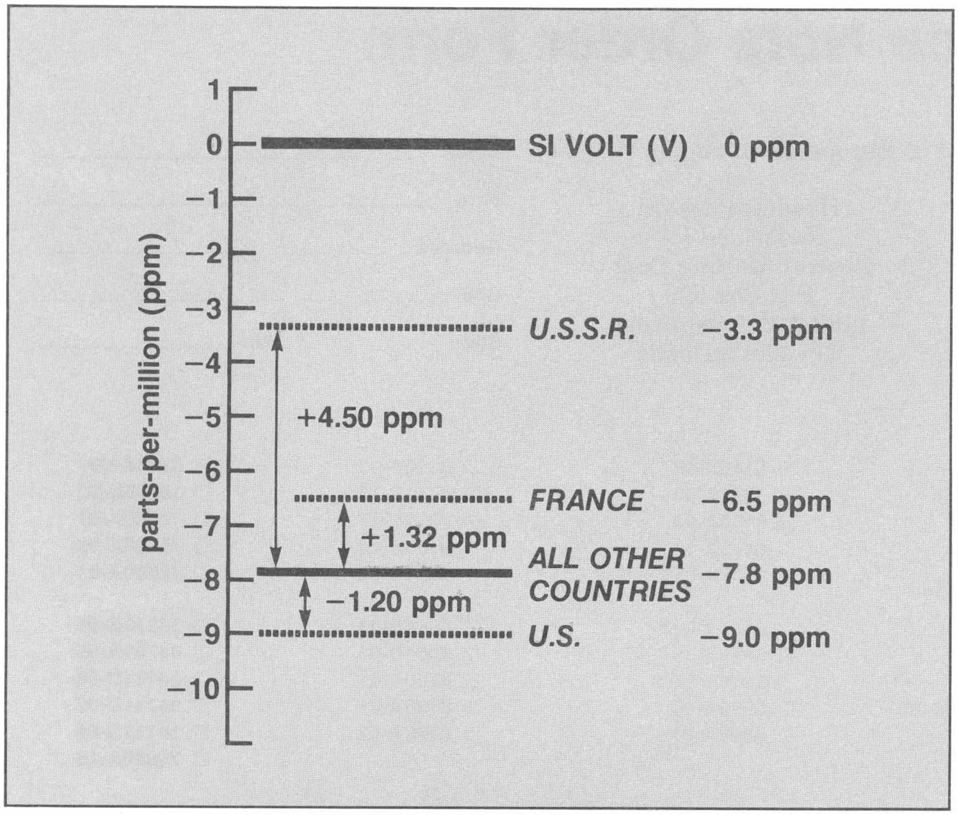

Figure 2. Graphical comparison of the representation of the SI volt of various countries based on the Josephson effect, V_{LAB}, and of V_{LAB} with the SI volt, V. The value of V_{LAB} indicated by 'All Other Countries' is based on the value of the Josephson frequency-voltage ratio $(2e/h)_{CCE-72}$ = 483594.0 GHz/V.

volt since 1969 and 483.5940 GHz/v was selected. One must be careful to use the proper constant when comparing voltage sources established by different nations. The 1990 change will remove this problem; all will start out with the same value.

Changes in the definition and realization of length have also had an effect on the electrical units. In 1889 (modified in 1927) the meter was defined by an artifact bar of platinum with 10 percent iridium. This definition was still in effect at the time of the 1948 change. To some people, the idea of an artifact—something solid—as a base for the electrical units gave comfort. In 1960, however, the definition of length changed to wavelengths of lights of the orange-red line of krypton 86. This change put the length value in terms of a fundamental physical constant that was not subject to damage, but removed the comfortable feeling offered by an artifact that could actually be touched. Based on proposals made in 1975 and realized later, the definition of length was changed in 1983 to be in terms of the velocity of light using a methane or iodine stablised helium-neon or argon laser (several combinations are possible). This change offered the possibility of more than an order of magnitude improvement in the length value and fixed the value of the velocity of light. Thus, length became a derived unit; the ohm is now based on the velocity of light.

Temperature and some other units have also played roles in the maintained values of the electrical units, but the effects have been generally quite small. Temperature and mass (USA only) will be subject to small changes in 1990 in addition to the changes of the ohm and the volt.

Problems encountered because of the 1990 changes seem to lie mostly in the understanding of it. The change is in the scaling factors by which we know the units. For example, a process that depends on a particular voltage will work the same after the change but the number by which we know the voltage will be a little different before and after. Measurement of that voltage by an instrument calibrated before the change will give a number that differs by the magnitude of the change from the number obtained by the same instrument calibrated afterwards. Most measurements are not at the 10 ppm level and will not see the change. However, we are now in the curious position that the resolution of our very fine measuring instruments equals or exceeds the uncertainty by which we can determine the magnitude of the values.

The history of the effort that has gone into establishing and maintaining the units is a most fascinating one. Additional information may be obtained from a variety of publications, especially those of the National Bureau of Standards. An example is *NBS Circular 475* by F. B. Silsbee on the electrical units, 1949. Among the authors are a number who have been active in the Instrumentation and Measurement Society; e.g., Dr. C. H. Page, and Dr. F. C. Harris. A short and concise history of the early times is given in Chapter 1 of *Basic Electrical Measurements* by Melville B. Stout, Prentice Hall, 1950. □

Safety-Related Service Notes

Service notes from HP relating to personal safety and possible equipment damage are of vital importance to our customers. To make you more aware of these important notes, they are printed on paper with a red border, and the service note number has a "-S" suffix. In order to make you immediately aware of any potential safety problems, we are highlighting safety-related service notes here with a brief description of each problem. Also, in order to draw your attention to safety-related service notes on the service note order form at the back of *Bench Briefs,* each appropriate number is highlighted by being printed in color.

HP 3065H/HX Board Test Systems

This Product Safety Service Note applies to HP 3060A, 3061A, 3062A 3065H and 3065HX Board Test Systems equipped with the HP 11253A/B Power Distribution Units. A safety problem exists in HP 3065H/HX systems with serials 2543A00258 and below, except 2543A00245, 2543A00246, and 2543A00257. The problem involves intended or accidental application of UNSWITCHED ac power from J21 or J22 of the HP 11253A/B Power Distribution Unit to a test fixture. If the cable intended for J2 (ac DUT power cable) is incorrectly connected to either J21 or J22, unswitched ac power will be connected to the test fixture. Contact with unswitched ac power could result in a possible shock hazard.

Hewlett-Packard has developed a hardware modification for this problem. Please contact your nearest HP office, or order Product Safety Service Note 3065-58-S through *Bench Briefs* for more information.

HP 8562A Spectrum Analyzer

A potential shock hazard may exist if the power line ground connection to a protective earth terminal is defeated. Please order Product Safety Service Note 8562A-1-S for modification instructions. Safety modification kit P/N 08562-60053 will be provided free of charge. □

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supplement to

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Here's the latest listing of service notes. They recommend modifications to Hewlett-Packard instruments to increase reliability, improve performance, or extend their usefulness.

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The part numbers for the service note microfiche library and subscription service are:

Library—	5951-6511
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Contact your local HP Sales Office for ordering information. □

HP 438A POWER METER

438A-4A. Serial prefix 2743A and below. Recommended A3 microprocessor board replacement (P/N 00438-60105).

HP 1650A/1651A LOGIC ANALYZER

1650/1651A-4. 1650A serials: 2801A01544 and below. 1651A serials: 2801A00643 and below. New keyboard housing to improve cosmetics and static discharge.

HP 3065 BOARD TEST SYSTEM

3065-20A. All serials. Repair of the external vacuum module P/N 03065-80602.

3065-52. All serials. Solutions for hybrid card relay failures.

3065-53. Serial numbers. All CX and CL Controller serial numbers presently under Software and Material Support Contracts, and presently running Software revisions CX/CL 1.1 or CX/CL 2.0. Installation of Software Revision 3.0.

3065-54. All serials. Pulser power supply capacitor failures.

3065-57. All HP 3065CX/CL Systems being updated to Rev. 3.0. Instructions for installing MUX card ROMS during the HP 3065CX/CL Rev. 3.0 Software Update Procedure.

3065-58-S. Serial numbers: HP 3065HXs 2543A00258 and below, except 2543A00245, 2543A00246, and 2543A00257. **Warning**—possible shock hazard. If the cable intended for J2 (AC DUT Power Cable) is incorrectly connected to either J21 or J22, unswitched AC power will be connected to the test fixture.

3065-60. All serials. Modifications to the 5, 15, 24 volt power supplies to improve performance.

HP 3455A DIGITAL VOLTMETER

3455A-18B. Serials 1622A09090 and below. Recommended replacements of A10 FETs Q1, Q2, Q3, Q4, Q13, Q14, Q15, Q16, Q18, Q19, Q21, Q38, Q39.

HP 3456A DIGITAL VOLTMETER

3456A-13A. Serials 2201A05331 and below. Modification to improve digital circuitry.

3456A-14A. Serials 2201A06299 and below. Modification to enhance analog circuitry.

3456A-15B. Serials 2201A04796 and below. Modification to enhance main controller board (A4).

HP 3488A SWITCH/CONTROL UNIT

3488A-12. Extended hardware support (1 June 1990) for power supply failures.

HP 3709A CONSTELLATION DISPLAY

3709A-7. All serials. Keyboard link position information for retrofit kits.

HP 3764A DIGITAL TRANSMISSION ANALYZER

3764A-23. All serials. Data inputs adjustment procedure.

HP 3780A PATTERN GENERATOR AND ERROR DETECTOR

3780A-34. Serials 2725U03943 and below. Preferred replacement of A35 assembly on options 100, 101, 103 and 104.

HP 4063A SEMICONDUCTOR PARAMETER ANALYSIS SYSTEM

4063A-4. All serials. Repair procedure for switching matrix.

HP 4145A/B SEMICONDUCTOR PARAMETER ANALYZER

4145A-12/4145B-3. All serials. New SMU board installation procedure.

HP 5340A MICROWAVE FREQUENCY COUNTER

5340A-13B. Serial prefixes 1928A and below. New A17 direct count amplifier to improve performance.

HP 5345A ELECTRONIC COUNTER

5345A-40. Serial prefixes below 2648A. Solution to low frequency miscount problem.

HP 5507A LASER POSITION TRANSDUCER ELECTRONICS

5507A-2. Serials 2816A00370 and below. Revised A1 HP-IB interface board to improve HP-IB performance.

HP 8175A DIGITAL SIGNAL GENERATOR

8175A-2. Serials 2642G00715 and below. Modification to increase the reliability of the A/B amplitude Vernier control circuit.

HP 8443A TRACKING GENERATOR/COUNTER

8443A-11. All serials. Modification of the crowbar overvoltage protection circuit triggering when switching from standby to on.

HP 8447A 0.1 TO 400 MHz PREAMPLIFIER

8447A-1A. Serial prefix 2809A and below. Recommended 400 MHz preamplifier replacement.

HP 8447A DUAL PREAMPLIFIER

8447A-2A. Serial prefix 2809A and below. Recommended 400 MHz preamplifier replacements.

HP 8557A SPECTRUM ANALYZER

8557A-16. Serial prefix 2507A through 2728A. Modification to improve residual FM performance in swept mode.

HP 8562A SPECTRUM ANALYZER

8562A-1-S. Serials:

2703A00223	2703A00295
2703A00224	2703A00296
2703A00238	2703A00299
2703A00252	2703A00300
2703A00263	2703A00308
2703A00290	2703A00310
2703A00294	2703A00329

Possible shock hazard. The chassis of some HP Model 8562A's could float at +175 Vdc relative to power line neutral if the protective earth ground is defeated.

HP 8590A SPECTRUM ANALYZER

8590A-8. Serials 2736A002155 and below, and 2735U000616 and below. Modification to prevent 3 MHz RBW distortion.

8590A-10. Serials 2753A02568 and below. Modifying the RS-232 I/O assembly A21 to operate with a standard HP 13242G RS-232 cable.

HP 8592A SPECTRUM ANALYZER

8592A-2. Serials 2805A00479 and below. Modifying the RS-232 I/O assembly A21 to operate with a standard HP 13242G RS-232 cable.

HP 8673C/D SYNTHESIZED SIGNAL GENERATOR

8673C-16. Serial prefixes 2447A and below. Improved reliability for automatic level control 0.05 to 2 GHz.

8673D-17. Serial prefixes 2447A and below. Improved reliability for automatic level control 0.05 to 2 GHz.

HP 8683B/D SIGNAL GENERATOR

8683B-02. All serials. Oscillator assembly (A14) post repair adjustment procedure.

8683D-02. All serials. Oscillator assembly (A14) post repair adjustment procedure.

HP 8684B/D SIGNAL GENERATOR

8684B-05. All serials. Oscillator assembly (A14) post repair adjustment procedure.

8684D-03. All serials. Oscillator assembly (A14) post repair adjustment procedure.

HP 8720A NETWORK ANALYZER

8720A-1. All serials. Adjustments to optimize spurious responses and reduce FM sidebands on the source signal.

HP 8780A VECTOR SIGNAL GENERATOR

8780A-01. All serials. Firmware history and update kit.

8780A-02. Serial prefixes 2725A and below. Reduced carrier frequency offset for DCFM (except option 064).

8780A-03. All serials. Retrofitting option 002 (high power coherent carrier).

HP 10308B 6809/6809E INTERFACE MODULE

10308B-2. Incorrect clock specification. Modification to correct the clocking scheme so the interface functions properly when used with the HP1650A, HP1651A, or HP16510A logic analyzers.

HP 16500A LOGIC ANALYSIS SYSTEM MAINFRAME

16500A-1. Serials 2650A00345 and below. Incorrect fans installed in instruments.

16500A-2. Serials 2650A00425 and below. Cardcage modification to support current power supply revision.

16500A-3. Serials 2650A00550 and below. Place insulating tape on power supply screws to eliminate power recycling.

HP 37212B MODEM

37212B-01. Some units prior to 2740U00450. Modification to correct contents of internal registers when stuck at default values.

HP 44701A INTEGRATING VOLTMETER FOR THE HP 3852A

44701A-5. All serials. ACV operation verification and performance test "failures."

HP 54111D DIGITIZING OSCILLOSCOPE

54111D-4. Serial prefixes 2733A and below. New improved A1 timebase board (HP P/N 54111-66513) requires firmware revision of March 10, 1988 or later.

54111D-5. Serial prefixes 2733A and below. Replacing ADC board (HP P/N 54111-69501) may require firmware revision of March 10, 1988 or later.

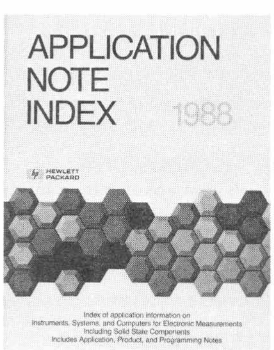
54111D-6. Serial prefixes 2733A and below. New A2 microprocessor assembly HP 54111-66517 replaces HP P/N 54111-66507 due to firmware update.

HP 70900A LOCAL OSCILLATOR

70900A-16. HP-MSIB change on the MEM+ controller board assembly to improve performance.

1988 Application Note Index is Now Available

Bill Dunaway
Corporate Marketing Services



The 1988 Application Note Index is now available. The index is a listing of over 600 free HP publications designed to help customers select and use HP electronic instruments, solid-state components, and systems as part of measurement and design solutions.

To direct customers to appropriate abstracts, which briefly describe individual HP publications, the index is categorized by industry, subject, and HP model number.

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- Application Bulletins and Briefs that cover the use of component products.
- Programming Notes that describe instrument control in systems environments; may be either introductory operating guides or quick reference guides.

Customers may obtain copies of the index (P/N 5954-0203) from the Customer Information Center in the U.S. or from local sales offices. The index primarily serves the test and measurement audience. However, some publications are listed that address technical computing topics and fundamentals. □

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2ND QUARTER 1988
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