HEWLETT PACKARD

BENCH BRIEFS

SERVICE INFORMATION FROM HEWLETT-PACKARD

1st Quarter 1996

Failure Modes of Digital ICs

Jim Bechtold/Hewlett-Packard

In order to troubleshoot efficiently, it is important to understand the type of failures found in digital circuits. IC failures can be categorized into two main classes; *internal* IC failure and a failure in the circuit *external* to the IC.

Internal Failures

There are four types of failures that can occur internally to an IC. These are:

- An open bond on either an input or output
- A short between an input or output and Vcc or ground
- A short between two pins (neither of which are Vcc or ground)
- A failure in the internal circuitry (often called the steering circuitry) of the IC

External Failures

In addition to these four failures internal to an IC, there are four failures that can occur in the circuit external to the IC. These are:

- A short between a node and Vcc or ground
- A short between two nodes (neither of which are Vcc or ground)
- An open signal path
- A failure of an analog component

Effects on Circuit Operation

The first failure internal to an IC mentioned was an open bond on either an input or output. This failure has a different effect depending upon whether it is an open *output* bond or an open *input* bond.

Open Output Bond

In the case of an open output bond (Figure 1), the inputs driven by that output are left to float. In TTL and DTL circuits a floating input rises to approximately 1.4 to 1.5 volts and usually has the effect on circuit operation as a high logic level. Thus an open output bond will cause all inputs driven by that output to float to a bad level since 1.5 volts is less than the high threshold level of 2.0 volts and greater than the low threshold level of .4 volt. In TTL and DTL, a floating input is interpreted as a high level. Thus the effect will be that these inputs will respond to this bad level as though it were a static high signal.

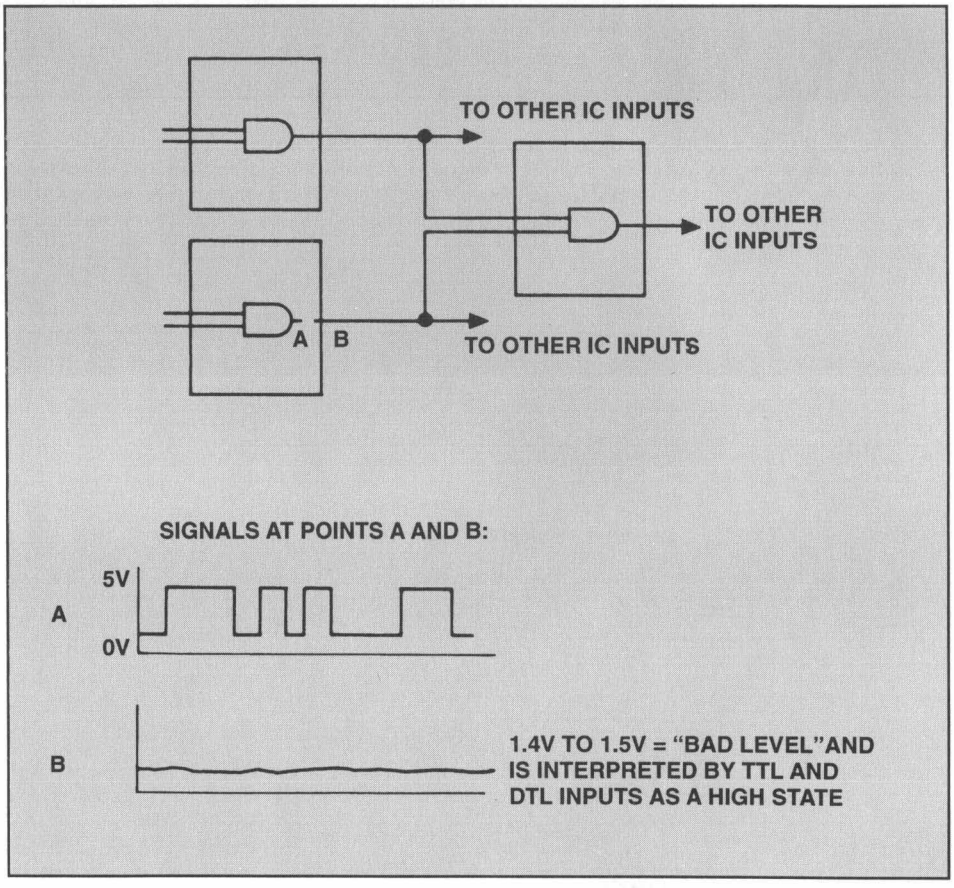

Figure 1. The Effect of an Open Output Bond Upon Circuit Operation. An open output bond allows all inputs driven by that output to float to a "bad level." This level is usually interpreted as a logic high state by the inputs. Thus the inputs driven by an open output bond will respond as though a static logic high signal was applied.

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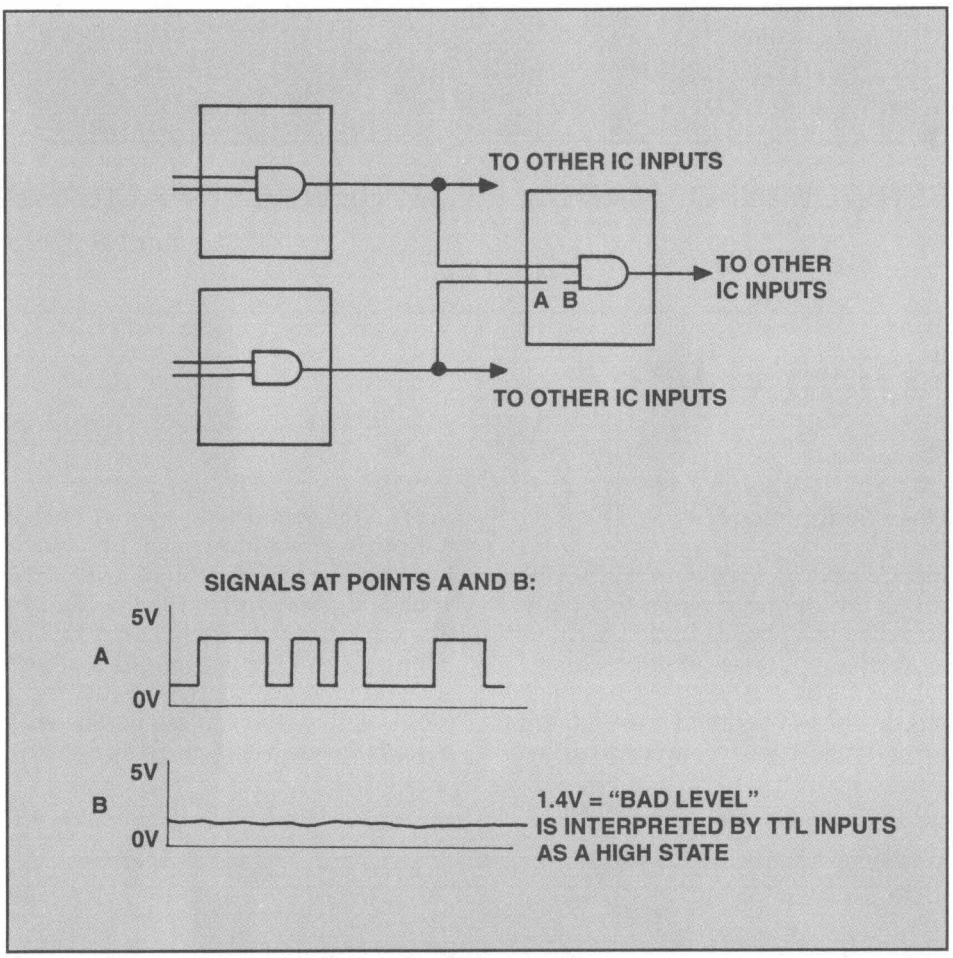

Figure 2. The Effect of an Open Input Bond Upon Circuit Operation. An open bond on an input has the effect of blocking the input signal from reaching the chip and allows the input of the chip to float to a "bad level." Thus even though the signal can be viewed at an external point such as Point A, the input of the chip responds to the "bad level" as though it were a static high level.

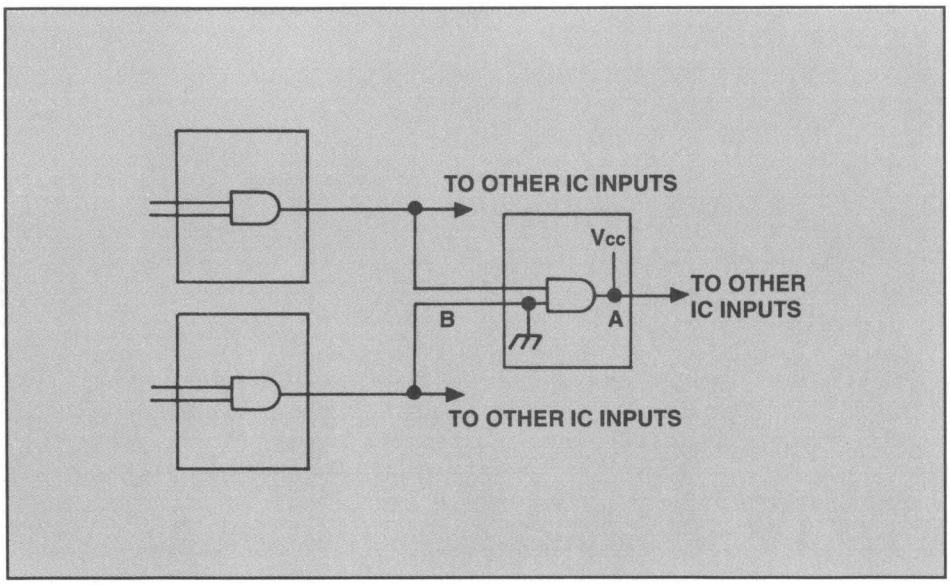

Figure 3. The Effect of a Short Between an Input or Output and Vcc or Gnd. All signal lines connected to Point A are held in the high state. All signal lines connected to Point B are held in the low state.

Open Input Bond

In the case of an open input bond (Figure 2), we find that the open circuit blocks the signal from entering the IC chip. The input on the chip is thus allowed to float and will respond as though it were a static high signal. It is important to realize that since the open occurs inside the IC, the digital signal driving this input will be unaffected by the open and will appear normal when looking at input pin A (Figure 2). The effect will be to block this signal inside the IC and the resulting IC operation will be as though the input were a static high.

Short Between Input/Output/Vcc/Ground

A short between an input or output and Vcc or ground has the effect of holding all signal lines connected to that input or output either high (in the case of a short to Vcc) or low (if shorted to ground) (Figure 3). In many cases, this will cause expected signal activity at points beyond the short to disappear and thus this type of failure is catastrophic in terms of circuit operation.

Short Between Two Pins

A short between two pins is not as straightforward to analyze as the short to Vcc or ground. When two pins are shorted the outputs driving those pins oppose each other when one attempts to pull the pins high while the other attempts to pull them low (Figure 4). In this situation the output attempting to go high will supply current through the upper saturated transistor of its totem pole output stage while the output attempting to go low will sink this current through the saturated lower transistor of its totem pole output stage. The net effect is that the short will be pulled to a low state by the saturated transistor to ground. Whenever both outputs attempt to go high simultaneously or to go low simultaneously, the shorted pins will respond properly. But whenever one output attempts to go low the short will constrained to be low.

Failure of Internal Circuitry

The fourth failure internal to an IC is a failure of the internal steering circuitry of the IC (Figure 5). This has the effect

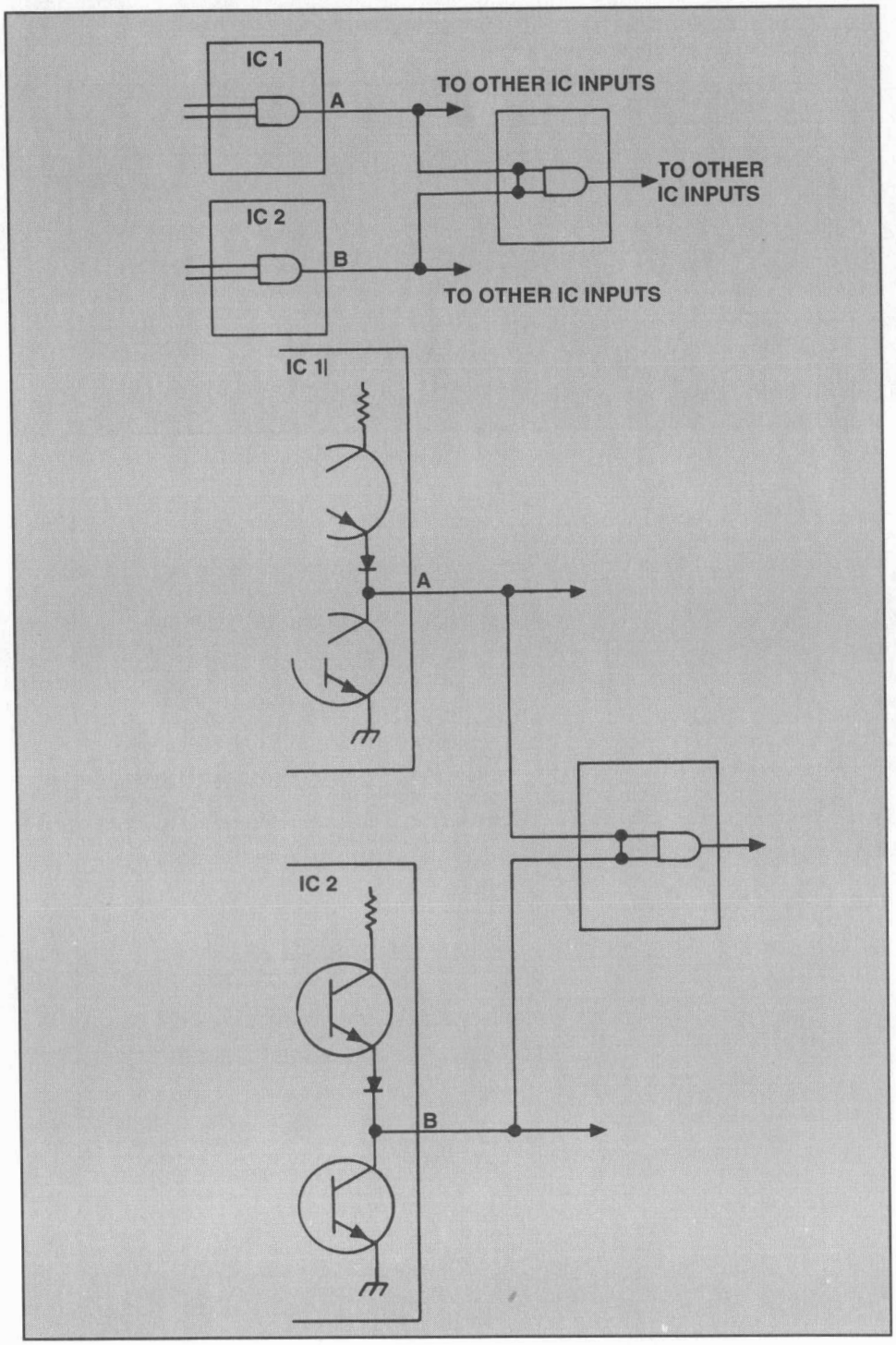

Figure 4. Short Between Two Pins. The error effect of a short between two pins occurs when the outputs driving those pins attempt to pull the short to opposite states. In this case, the output attempting to pull the node high will be supplying current while the output attempting to pull the node low is a saturated transistor to ground and will be sinking the current. The saturated transistor to ground will thus pull the node to a low state.

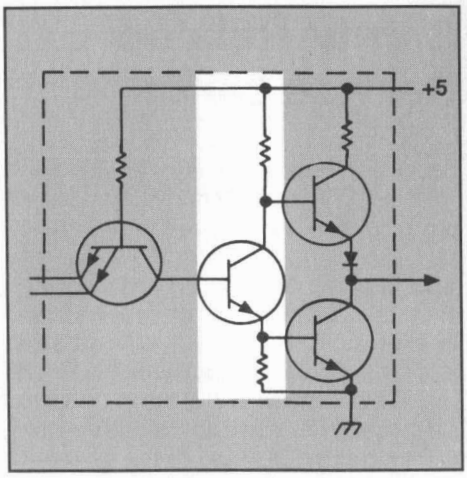

Figure 5. The Effect of a Failure of the Internal Circuitry of the IC Upon Circuit Operation. A failure of the steering circuitry of an IC will either cause the output to be in a static high state or a static low state.

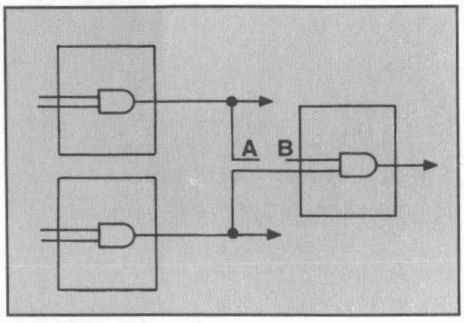

Figure 6. The Effect of an Open in the Circuit External to an IC. All inputs attached to the node at Point A will be driven properly. All inputs to the right of the open (Point B) will be left to float to a "bad level" and will therefore look like a static high state.

of permanently turning on either the upper transistor of the output totem pole thus locking the output in the high state or turning on the lower transistor of the totem pole thus locking the output in the low state. Thus this failure blocks the signal flow and has a catastrophic effect upon circuit operation.

External Failures

A short between a node and Vcc or ground external to the IC is indistinguishable from a short internal to the IC. Both will cause the signal lines connected to the node to either always high (for shorts to Vcc) or always low (for shorts to ground). When this type of failure is encountered only a very close physical examination of the circuit will reveal if the failure is external to the IC. An open signal path in the circuit has a similar effect as an open output bond driving the node (Figure 6). All inputs to the right of the open will be allowed to float to a bad level and will thus appear as a static high level in circuit operation. Those inputs to the left of the open will be unaffected by the open and will thus respond as expected. □

Safety-Related Service Notes

Service Notes from Hewlett-Packard 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 an "-S" suffix. In order to make you immediately aware of any potential safety problems, we are re-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 in the service note index, each safety-related service note is highlighted with a contrasting color.

HP 85942A Video Signal Monitor

Serial Numbers Affected:

0000U00000/3512U00160

Situation:

These instruments have two wires that come out of the power supply line module and go to the power supply assembly. With the current routing these wires pass close to capacitor C25 on the power supply assembly. The wires are properly insulated; however, a break in the insulation could conceivably result in a safety problem. This is a MINIMAL risk, but is noted here as a product reliability improvement. For more information, request safety service note 8942A-01-S from HP First as document id 6492.

Table 1. Logic analyzers and digitizing oscilloscopes to be inspected/ repaired for potential electric shock.

HP Model Number	PSSN Number	Serial Numbers of Suspect Instruments
1660A	1660A-02-S	3338A00899 / 33338A00899
		US34510130 / US34510208
		US35240101 / US35240204
1661A	1661A-02-S	3338A01330 / 3338A01330
		US34510105 / US34510299
		US35240101 / US35240275
1662A	1662A-02-S	3338A01118 / 3338A01132
		US34510124 / US34510287
		US35240101 / US35240265
1663A	1663A-02-S	3338A00849 / 3338A00854
		US34510113 / US34510244
		US35240101 / US35240232
1660AS	1660AS-02-S	3339A00137 / 3339A00333
		US34510101 / US34510210
		US35240101 / US35240204
1661AS	1661AS-02-S	US34510121 / US34510190
		US35240101 / US35240186
1662AS	1662AS-02-S	US34510145 / US34510209
		US35240101 / US35240212
1663AS	1663AS-02-S	US34510156 / US34510184
		US35240101 / US35240156
1660C	1660C-01-S	US35350101 / US35350137
1661C	1661C-01-S	US35350101 / US35350168
1662C	1662C-01-S	US35310101 / US35310155
1663C	1663C-01-S	US35310101 / US35310137
1660CS	1660CS-01-S	US35350101 / US35350187
1661CS	1661CS-01-S	US35350101 / US35350152
1662CS	1662CS-01-S	US35350101 / US35350136
1663CS	1663CS-01-S	US35310101 / US35310118
1664A	1664A-01-S	US34390180 / US34390199
		US35240101 / US35240249
1670A	1670A-01-S	US35340101 / US35340112
1671A	1671A-01-S	US35340101 / US35340111
1672A	1672A-01-S	US35340101 / US35340109
54501A	54501A-06-S	3251A16271 / 3251A16271
		3251A16418 / 3251A16418
		US34510113 / US34510295
54502A	54502A-07-S	3251A06549 / 3251A06549
		US34510117 / US34510219

Table 1. (continued)

HP Model Number	PSSN Number	Serial Numbers of Suspect Instruments
54503A	54503A-06-S	3309A06682 / 3309A06682
		US34510174 / US34510431
54504A	54504A-03-S	US34510122 / US34510271
54510B	54510B-03-S	3218A01007 / 3218A01007
54512B	54512B-03-S	3218A00822 / 3218A00822
54520A	54520A-02-S	US34360585 / US34360898
		US35240101 / US35240168
		US35300101 / US35300363
		US35480101 / US35480232
54522A	54522A-02-S	3443A00304 / 3443A00304
		3414A00380 / 3414A00380
		3414A00388 / 3414A00388
		US34360139 / US34360438
		US35240101 / US35240128
		US35300101 / US35300204
		US35480102 / US35480198
54540A	54540A-02-S	US34360193 / US34360427
		US35240110 / US35240122
		US35300104 / US35300204
		US35480101 / US35480138
54542A	54542A-02-S	3415A00678 / 3415A00678
		US34360177 / US34360597
		US35240109 / US35240119
		US35300103 / US35300194
		US35480101 / US35480145
54520C	54520C-02-S	US35130124 / US35130159
		US35240101 / US35240128
		US35300101 / US35300118
		US35480102 / US35480132
54522C	54522C-02-S	US35020103 / US35020120
		US35300102 / US35300145
		US35480101 / US35480117
54540C	54540C-02-S	US35130101 / US35130109
		US35140110 / US35140127
		US35300101 / US35300156
		US35480101 / US35480127
54542C	54542C-02-S	US35020106 / US35020230
		US35240103 / US35240142
		US35300101 / US35300251
		US35480101 / US35480174

HP E7080A/81A/82A Semiconductor Test Systems

Serial Numbers Affected:

All systems.

A potentially faulty primary AC wire connection can result in over heating of system power connections to the point of melting. For more information, request safety service note E7080A/81A/82A-01-S from HP First as document id 6510.

HP 16xx Logic Anayzers and HP 545xx Digitizing Oscilloscopes

Model Numbers and Serial Numbers Affected:

See Table 1.

Situation:

The condition for possible electric shock results from a potential short within the line filter assembly. The fault can be caused by solder fragments within the line filter moving and shorting the line to earth ground. This condition may result in an electrical shock by elevating the instrument to a hazardous voltage if the safety ground is faulty or is disconnected.

Hewlett-Packard strongly recommends that you return the instrument immediately to the nearest HP Customer Repair Center for inspection, and if required, repair at no charge. For more information, you may order a safety service note document from HP First. For the logic analyzers, order document id 6386; for the digitizing oscilloscopes, order document id 6410. □

1996 Bench Briefs' Instrument Service Note Index

HP FIRST (208)344-4809
T & M Instrument Section - Press 4
T & M Service Notes - Press 2
Enter the Password - 76683

SN Type	SN No.	Abstract	HP FIRST Document ID No.
MA	10887A-02	Performance upgrade to 1 m/s slew rate capability	6383
MR	11757B-03	Mod corrects error in CCIR dispersive fade mrgn algor	6384
MR	11758B-03	Mod corrects error in CCIR dispersive fade mrgn algor	6385
MR	1660AS-01	Instructions on reloading S/W to correct Flash ROM failure	6132
PS	16xxX-xx-S	Logic Analyzers. Potentially def line filter may cause shock hazard	6386
MR	3245A-01A	Mod to correct the square wave symmetry test specification	6387
IO	34401A-06	Display assy replacement requires compatible F/W	6388
IO	3561A-10	A91 replaces A90, requiring A99 modification	6389
MR	37717B-03	Inst fails to power-up due to PSU module prob	6390
MR	4155A-02	New power supply prevents shut-down failures	6113
IO	4286A-01	Bit switch settings of the A1 CPU board	6391
MR	4286A-02	F/W upgrade corrects AUTOREC_S / CALREC_C problem	6392
MR	438A-13	Mod eliminates measurement instability	6393
IO	5071A-04	FAQ about the 5071A internal batteries	6394
MR	5071A-05	A11 failure can cause loss of internal battery capacity	6395
MR	5071A-06	Mod to prevent A12 DC-to-DC converter input failure	6396
MR	5071A-07	Nylon barrel retrofit prevents A11 damage	6397
MA	5328A-43	Mod reduces TBOut error in Opt 040 or 041 units	6398
MA	5328B-05	Mod reduces TBOut error in Opt 040 or 041 units	6399
MR	5347A-10	Replacement Teflon barrel guide for fused BNC connector	6400
MR	5348A-10	Replacement Teflon barrel guide for fused BNC connector	6401
MR	5350B-08	Replacement Teflon barrel guide for fused BNC connector	6402
IO	54121A-02B	TDR system specification change	6403
IO	54123A-01	TDR system specification change	6404
IO	54124A-01	TDR system specification change	6405
IO	54520C-03	How to set the screen saver feature	6406
IO	54522C-03	How to set the screen saver feature	6407
IO	54540C-03	How to set the screen saver feature	6408
IO	54542C-03	How to set the screen saver feature	6409
PS	545xxX-xx-S	Digitizing Scopes. Potentially def line filter may cause shock hazard	6410
IO	54600B-03	New attenuator cover design	6411
IO	54600B-04	New calibration routine for voltage measurement accuracy	6412
IO	54600B-05	New text limits for horizontal delta-t and (delta-t)^-1	6413
IO	54601B-03	New attenuator cover design	6414
IO	54601B-04	New calibration routine for voltage measurement accuracy	6415
IO	54601B-05	New test limits for horizontal delta-t and (delta-t)^-1	6416
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IO	54603B-04	New test limits for horizontal delta-t and (delta-t)^-1	6422
IO	54610B-03	New calibration routine for voltage measurement accuracy	6423
IO	54610B-04	New test limits for horizontal delta-t and (delta-t)^-1	6424
IO	54610B-05	Internal trigger specification change	6425
IO	54753A-01	TDR system specification change	6426
IO	54754A-01	TDR system specification change	6427
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MA	5517B/C/D-03	Replace fast-blow with slow-blow fuse	6428
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MA	5519A/B-01	Upgrade increased slew rate capability	6430
IO	6051A-01A	Rec procedure for fan speed adjustment	5684

SN Type	SN No.	Abstract	HP FIRST Document ID No.
MR	6545A-01	Replace capacitor C418 to prevent failures	6431
IO	6573A-01	Recommended repl parts for FETs Q901 and Q902	6432
IO	6574A-01	Recommended repl parts for FETs Q901 and Q902	6433
IO	6575A-02	Recommended repl parts for FETs Q901 and Q902	6434
MR	66101A-03	New F/W corrects status before delay problem	6435
MR	66101A-04	New F/W corrects OCP occurring before Output off	6436
MR	66101A-05	New F/W makes List Mode work from the keyboard	6437
MR	66102A-02	New F/W corrects status before delay problem	6438
MR	66102A-03	New F/W corrects OCP occurring before Output off	6439
MR	66102A-04	New F/W makes List Mode work from the keyboard	6440
MR	66103A-02	New F/W corrects status before delay problem	6441
MR	66103A-03	New F/W corrects OCP occurring before Output off	6442
MR	66103A-04	New F/W makes List Mode work from the keyboard	6443
MR	66104A-03	New F/W corrects status before delay problem	6444
MR	66104A-04	New F/W corrects OCP occurring before Output off	6445
MR	66104A-05	New F/W makes List Mode work from the keyboard	6446
MR	66105A-03	New F/W corrects status before delay problem	6447
MR	66105A-04	New F/W corrects OCP occurring before Output off	6448
MR	66105A-05	New F/W makes List Mode work from the keyboard	6449
MR	66106A-02	New F/W corrects status before delay problem	6450
MR	66106A-03	New F/W corrects OCP occurring before Output off	6451
MR	66106A-04	New F/W makes List Mode work from the keyboard	6452
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IO	6673A-03	Recommended repl parts for FETs Q901 and Q902	6454
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IO	6675A-04	Recommended repl parts for FETs Q901 and Q902	6456
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IO	6683A-01	Recommended repl parts for FETs Q901 and Q902	6458
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MR	70908A-25	New adjustment S/W reduces SYTFMD discrim unlock errors	6461
MR	83751A-01	Inspection and replmnt of rubber air dam attached to fan	6462
MR	83752A-01	Inspection and replmnt of rubber air dam attached to fan	6463
MR	83752B-01	Inspection and replmnt of rubber air dam attached to fan	6464
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MR	85462A-04	EPROM F/W upgrade corrects stepped measurements	6468
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MR	8560E-13	Intermittent flashing display intensity	6470
IO	8561E-08	VCO adjmnt for later "1X6" A15 RF assemblies	6471
MR	8561E-10	Intermittent flashing display intensity	6472
MR	8563E-10A	Possible frequency response drift	6473
IO	8563E-12	VCO adjmnt for later "1X6" A15 RF assemblies	6474
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MR	8564E-04A	Possible frequency response drift	6476
IO	8564E-06	VCO adjmnt for later "1X6" A15 RF assemblies	6477
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MR	8565E-04A	Possible frequency response drift	6479
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MR	8591E-09	New F/W Rev K 95.09.14 corrects previous problems	6488
MR	8592L-04	New F/W Rev K 95.09.14 corrects previous problems	6489
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MR	8593E-11	New F/W Rev K 95.09.14 corrects previous problems	6491
SA	85942A-01-S	Line module wire rerouting prvnts possible safety prob	6492

SN Type	SN No.	Abstract	HP FIRST Document ID No.
MR	8594E-10	Mod corrects overshoot problem in power vs time meas	6493
MR	8594E-11	New F/W Rev K 95.09.14 corrects previous problems	6494
MR	8595E-10	Mod corrects overshoot problem in power vs time meas	6495
MR	8595E-11	New F/W Rev K 95.09.14 corrects previous problems	6496
MR	8596E-10	Mod corrects overshoot problem in power vs time meas	6497
MR	8596E-11	New F/W Rev K 95.09.14 corrects previous problems	6498
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MR	E3610A-04	Mod elims V trans above output set during turn-off	6504
MR	E3611A-05	Mod elims V trans above output set during turn-off	6505
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MR	E5100A/B-01	Mod corrects marker target search problem	6509
SA	E7080A/81A/82A-01-S	Semicon Test Sys. Faulty twist-lock AC connectors may cause shock/fire	6510

Service Note Types

IO	Information Only	SA	Safety
MA	Modification Available	PS	Priority Safety
MR	Modification Recommended		

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