



HP CEO SITE PREP HANDBOOK

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PREFACE

This book was written for the the HP Customer Engineer (CE) who does site preparations for computer customers. It is part policies and procedures, part reference matter, and part product specifications.

Section 1, Introduction, describes the nature of the site prep job, analyzes the phrase "recommended specification", and introduces two rules that apply at all times, in all places, under all circumstances.

Section 2, Before the Planning Visit, suggests planning ideas for the CE before his/her first customer call.

Section 3, The Site Planning Visit, contains the bulk of the book's suggested procedures. During the planning visit, the CE checks conditions where system components will be stored until all integrated shipments arrive; checks the path from the storage area to the computer room; and then checks the computer room's electrical, physical, and environmental conditions. Along the way, the CE explains HP's recommended specs to the customer, and when needed offers suggestions as to how those specs can be met.

Section 4, The Site Survey, focuses on the line treatment device education the CE gives the customer whose site's power needs upgrading to meet HP's recommended specs.

Section 5, Tools, contains articles on the use of site prep tools.

Several appendices of reference material follow Section 5. These range from questions-and-answers, to escalation procedures, to electrical codes, to product specs, to an appendix reserved for contributions from CEs themselves.

Throughout the book, emphasis is placed on identifying where HP's responsibilities begin and end. Explicit answers are provided for such common questions as: "Can I tell the customer to remove his carpeting?" and "Am I supposed to tell the customer what size air conditioner to buy?"

INTRODUCTION

SECTION

1

OVERVIEW

The purpose of site preparation is to prevent HP product failures caused by the customer's environment.

That is what you, the HP Customer Engineer (CE), are trying to accomplish by inspecting the customer's site for things like power, temperature, and Electrostatic Discharge. (In this book, "CE" includes CEs, TSEs, or any other HP representatives who do customer site prep.) The purpose of this book is to describe HP Computer Group site prep policies and procedures so CEs everywhere in the world can apply them uniformly and consistently. This book presumes the reader has some Account CE experience and has at least an elementary education in AC power.

HP's reputation for selling reliable equipment results not only from its design and manufacture, but also from the time we spend ensuring that it operates in a satisfactory environment. In other words, the environment must be controlled. And we must give the customer the same recommended specs for that control wherever he or she is located.

'RECOMMENDED SPECIFICATIONS'

This book uses the words "recommended specification" in a manner consistent with the Customer Support Services Agreement (CSSA). Paragraph 4.6 of the CSSA reads: "HP shall be under no obligation to furnish support services under this Agreement should repair be required because of failure by Customer to maintain the site specifications recommended by HP. If support services are required as a result of the causes stated above, such service shall be provided at HP's standard service rates for labor, travel, and material in effect at the time of service." In short, if the customer wants a service contract, the site must meet HP's recommended specs.

For example: the HP 3000 Series 68 SPU has a recommended operating humidity spec of 40 to 60 percent. (It also has a minimum/maximum range of 30 to 80 percent. That means it can operate in the 30 to 80 range as long as 48 hours, but that should not be confused with the 40 to 60 percent recommended range.) Assume the humidity at a customer's site is usually around 70 percent. If the customer wants a CSSA, the humidity must be brought down at least to 60 percent. If not, HP is not obligated to provide a CSSA. With no CSSA, the

Introduction

customer would be charged for repairs for any hardware problem that occurs on the system.

NOTE

Keep in mind that the question of coverage under a CSSA arises in very few cases. We want customers to understand that their sites should meet our recommended specs because, first, that will ensure best computer system performance, and only secondly because that's how they qualify for a service contract. We want customers' systems to provide dependable, reliable service; you are there to help them understand how they can help make that happen.

SITE PREP CE PHILOSOPHY

Before getting into procedures, it is vital that the CE doing site prep understands certain things about the nature of the job. Experienced CEs already understand them, but if your experience is limited, here is a truth you may not yet have realized: As a site prep CE, at least half your activities will consist of educating customers.

This means that if a customer is going to understand why his site should meet our recommended specs, you must educate him on the benefits. Does he want a long-term reliable computer? Does he want to keep his down-time to a minimum? Of course he does. Wouldn't he rather spend his money on new equipment than on repairs for the existing equipment? Of course he would. You have to help him understand that over the long run his computer is going to work most reliably if his site meets HP's recommended specs.

You will find that there will always be decisions to be made, using judgment and experience. Some of these decisions are discussed in Appendix A, Questions and Answers, but we've already touched on one of them. The preceding Paragraph titled "Recommended Specifications" has been thoroughly analyzed, but still contains some generalizations, like the site having a humidity level "usually around" 70 percent. Your question is, how do you decide what "usually around" is? If the humidity level slides up and down as people come and go from the computer room, leaving the doors open, how usual is usually? If there is any disagreement, where do you draw the line?

The answer is: you don't -- at least not alone. If you have done your best to educate the customer on the benefits of making the site meet HP's recommended specs, but there is still a question of

interpretation, or disagreement, get your district manager involved immediately. He or she, then, may wish to follow PRSD's suggested Site Environment Escalation Procedure. That procedure is described in Appendix B of this handbook, for reference only. Any action under the escalation procedure should be initiated by your district manager.

Please re-read the "Recommended Specifications" Paragraph occasionally, so we all use those words the same way. Most importantly, remember that the customer should make the site meet the recommended specs first, to get best performance from her computer, and only secondly because that's how she gets a service contract. Throughout the rest of this manual, we will assume your customer understands the advantages of making the site meet HP's recommended specs (and wants a CSSA).

GENERAL RULES

Before proceeding, two general rules must be kept in mind during site preparation: the 'weakest link' rule and the 'rule of contradictions'.

The 'Weakest Link' Rule

You often find that one component in a system has tighter specs than others. In that case, the site must meet the recommendations for the "weakest link," i.e., the component with the tightest spec. For example, suppose the various components in your customer's system have three recommended operating temperature ranges: 68 to 78 degrees F, 59 to 95 degrees F, and 68 to 86 degrees F. What is the recommended operating temperature spec for the site? Answer: 68 to 78 degrees F.

The 'Rule of Contradictions'

You may occasionally encounter a building inspector who contradicts something you have learned at HP or even contradicts the National Electrical Code of your country. Local rule always takes precedence in such a case. Never suggest that a customer do something that contradicts a local code, or inspector's interpretation of that code.

BEFORE THE PLANNING VISIT

SECTION

2

This section describes the CE's planning process before the first visit to the site. It includes reviewing the customer's documentation, calculating the computer system power consumption and heat generation, and listing the physical dimensions of the system components.

REVIEWING THE CUSTOMER'S DOCUMENTATION

XYZ Co. just bought an HP Computer System and you are reviewing the order. The first thing you should do is determine whether the sales rep has given XYZ a site prep manual(s) from the HP division(s) that manufactured the equipment. If you know the habits of your sales reps, you may assume this has been done. If not, you should ask; and if the manual has not been given to XYZ, you may have to mail it or deliver it yourself.

After ensuring that the customer has the appropriate site prep manual, you should review a copy of it yourself, because the customer may ask about things in it that are touched on only briefly in this book. This book describes HP Computer Groups recommended specifications; i.e., it describes the power and environmental qualities HP Computer Systems need for maximum reliability. Some divisional customer site prep manuals include many details about floor polishes, fire protection, record classification, illumination, etc. As those subjects are not covered by HP specifications, they are only mentioned in this book.

After reviewing the customer's order and site prep manual, you are ready to calculate the system power consumption and heat generation. Knowing these things in advance makes it easier to determine, once at the site, whether the existing power and air conditioning are adequate. Some CEs take time to compile all system specs now. PRSD suggests power consumption and heat generation as a minimum. If nothing else, they serve as a check against any calculations you do on site with people rubbing against your elbows.

NOTE

There is a second reason for reviewing the customer's documentation. In some cases, your normal local site prep practices may be superseded by an agreement between HP and a major account customer. For example, a customer might buy 30 computer systems to be installed in 10 locations. The customer headquarters and the HP office serving it may agree on a standard site prep plan to be followed at all 10 locations. Problems can arise for two reasons: (a) - The HP office serving the headquarters does not notify the HP offices at all 10 locations that a standard plan was established; or (b) - A CE at one of the locations disagrees with the plan, and expresses his disagreement at the customer's local office. The HP office working with the customer's headquarters should ensure that all affected HP offices are notified of the plan. If a CE questions the plan, he should not do so in front of the customer; it damages HP's "one company" appearance. If a CE questions the plan, he should ask them within HP. By starting with his DCEM, the questions can be routed to the originating HP office. If no local code is violated, local practices may be modified to comply with the standard agreement.

POWER CONSUMPTION AND HEAT GENERATION

From the site prep perspective, the most important unit of power is Volt-Amps (VA). VA represents Apparent Power, the product of voltage and current, and is what people usually mean when they say "Watts". When people really mean Watts, they must include a Power Factor in the equation, as follows:

$$VA = V * I, \text{ and}$$

$$\text{Watts} = VA * \text{Power Factor};$$

where V = voltage in volts, and
I = current in amperes.

The Power Factor is the cosine of the phasor angle between voltage and current; Appendix C, Dirty Power and Solutions, goes into this in detail.

VA values are included in the information provided by the manufacturing divisions in Appendix Z, Product Specifications. Thus you need not do the arithmetic. However, you will probably try to reconcile the voltage and current values with the VA values listed, anyway. You'll probably also try to reconcile the VA values with the heat generation values. So let's step through the arithmetic.

Assume a product that requires a nominal input of three phase, 415V. Assume current is 10A per phase. What should the VA, BTU, and KCal values be?

Finding VA looks easy. We've already defined VA as the product of volts and amperes. It may seem all we need do is add the phase currents ($10 + 10 + 10 = 30$), then multiply 30 by 415. But it's not that simple with three phase products. The measurable voltage between any phase of a three phase supply and neutral ISN'T the nominal. It's the nominal divided by 1.73 (1.73 being the square root of 3).

$$415V / 1.73 = 240V.$$

$$\text{Thus, } VA = 240V * 30A = 7200VA.$$

Finding BTU/Hr takes two steps:

- 1 -- Find Watts. Remember that Watts = VA times Power Factor.
When Power Factor is unknown, assume .85.

$$\text{Watts} = 7200VA * .85 = 6120W.$$

- 2 -- BTU/Hr = Watts times 3.414.

$$6120W * 3.414 = 20894 \text{ BTU/Hr}.$$

In countries where Kilo-Calories (KCal) are used are used to measure heat, BTUs are converted to KCal by multiplying by .252. Thus:

$$20894 \text{ BTU/Hr} * .252 = 5265 \text{ KCal/hr}.$$

Before the Planning Visit

The "system" VA then, is the sum of the VAs for the components, and the system heat generation is the sum of the BTUs or KCals. If, when you inspect the site, you think it needs a power line treatment device, you can use the system VA as a starting point to help the customer decide approximately what size device to consider. Similarly, if the site needs temperature control, you can use the heat total as a starting point in steering the customer toward qualified air conditioning advice. More about line treatment devices and air conditioners in Sections 3 and 4. Let's list XYZ's components and the standard North American VA and BTU values from Appendix Z, as Table 2-1.

NOTE

The components used as examples in this book were picked strictly for practice using the specifications. No attempt was made to make them form a "realistic" system.

Table 2-1. XYZ Co. Power and Heat Values

COMPONENT	VOLT-AMPS	BTU/HR
HP 3000 Series 68B, part no. 32460B. Nominal input, three-phase 208V.	3968	12871
HP 2563A Printer. Nominal input, one-phase 120V.	230	853
HP 7976 Tape Drive. Nominal input, one-phase 117V.	1755	5992
HP 7935 Disc Drive. Nominal input, one-phase 120V.	1560	4437
TOTAL	7513	24153

PHYSICAL VALUES

One step in the site planning visit will be walking from the equipment storage area to the computer room to ensure that XYZ Co. has means to move the heaviest bay in the system, and that passageways and doors are wide enough for all bays. It is helpful to have the physical dimensions ready when you arrive, so refer again to Appendix Z. After adding these values to Table 2-1, it becomes Table 2-2. Where fractional values appear in the appendix, they are rounded up in the table. In the Height and Weight columns, only the tallest or heaviest individual bay is listed, assuming the components will be moved one bay at a time (then connected in the computer room). The "Width or Depth" column shows whichever dimension is narrower, as that is how the bay goes through a door.

Table 2-2. XYZ Co. Power, Heat, and Physical Values

COMPONENT	VOLT-AMPS	BTU/HR	TALLEST/HEAVIEST BAY		
			Height, inches	Narrower of Width or Depth, inches	Weight, pounds
HP 3000 Series 68B, part no. 32460B. Nominal input, three-phase 208V.	3968	12871	48	26	620
HP 2563A Printer. Nominal input, one-phase 120V.	230	853	11	18	75
HP 7976 Tape Drive. Nominal input, one-phase 117V.	1755	5992	63	25	560
HP 7935 Disc Drive. Nominal input, one-phase 120V.	1560	4437	33	22	340
TOTAL	7513	24153	--- Not Applicable ---		

SCHEDULING THE VISIT

You are now ready to phone the customer to arrange the site planning visit. Explain that you want to ensure that electrical and environmental conditions are conducive to maximum computer system reliability, and that you would like, if possible, to have the following people present: the site planning team leader (if one exists) or other policy-level manager; the computer system manager; the electrician or electrical contractor; the air conditioning contractor (if one exists); the building facilities manager; and/or anyone else who may make decisions about any site modifications that may be suggested. Depending on your local procedure, you may also invite the CE who will install the system, the sales rep, the account team leader, or some other member of the HP account team, to the meeting.

THE SITE PLANNING VISIT

SECTION

3

You are at XYZ Co. and you've met the site planning team. You've described the purpose of site prep (preventing HP equipment failures caused by the environment). During this visit you check conditions where system components will be stored until all integrated shipments arrive; check the path from the storage area to the computer room; and then check the computer room's electrical, physical, and environmental conditions.

CHECKING STORAGE AND MOVING CONDITIONS

Your main concerns here are (a) - that XYZ Co. has means to get the computer system off the shipper's truck; and (b) - that having gotten it at least as far as the receiving dock, they don't leave it there overnight in winter, or store it in an unheated, uninsulated, leaky warehouse. Special delivery instructions are required if the shipper must deliver the system in a truck with a drop tailgate, and the customer pays extra for this. If that is the case, notify XYZ's HP sales representative to make the arrangements.

With the computer system on XYZ property, the weakest link non operating temperature and humidity specs for the components take effect until the system is installed and brought up.

Checking Appendix Z, you find the non operating temperature specs for XYZ Co.'s components are:

Series 68B: -40 to 75 degrees C, -40 to 167 degrees F. (For the record, yes, -40 degrees C equals -40 degrees F; -40 is the one place the two scales intersect.)

2563A: -55 to 75 degrees C, -67 to 167 degrees F.

7976: +2 to 50 degrees C, 35 to 122 degrees F.

7935: -40 to 65 degrees C, -40 to 149 degrees F.

Thus the weakest link non operating temperature spec for the system is established by the 7976, at 2 to 50 degrees C, 35 to 122 degrees F.

The Site Planning Visit

Returning to Appendix Z, you find the non operating humidity specs for XYZ Co.'s components are:

Series 68B: 30 to 80 percent (all values are non condensing).

2563A: (Not Available)

7976: Any, non condensing.

7935: 5 to 95 percent

Thus the weakest link non operating humidity spec for the system is established by the Series 68B, at 30 to 80 percent, non-condensing.

NOTE

If it appears temperature and/or humidity levels in the storage area will approach the extremes, advise the customer to move the equipment to the computer room as soon as possible. This should be done at least a day before installation, to allow the system to become conditioned to its new environment. Also, be aware that some customer site prep manuals include "psychrometric charts" which attempt to show the relationship between temperature, humidity, and condensation. Interpreting the charts is tricky, however, as condensation is not a function of just one temperature at one humidity level. Condensation forms when temperature drops. The best advice for the customer is to move the equipment to the computer room as soon as possible, and definitely do not power-up any equipment until it has had ample time to acclimate itself to its new environment. (Obviously, it shouldn't be powered-up until the CE arrives to install it anyway.)

THE ROUTE TO THE COMPUTER ROOM

You want to ensure that XYZ Co. has means to lift the heaviest component in the system and move it to the computer room. Checking Table 2-2, the heaviest single bay in the system belongs to the Series 68B, at approximately 600 pounds. If the computer room is on a different floor, does XYZ have a freight elevator? If not, HP can arrange to have the shipper deliver the system to the other floor, at extra cost to XYZ. If XYZ wants that done, contact their HP sales representative to make the arrangements.

Dimensionally, the tallest system component is the 7976, at 63 inches; and the worst case of width of depth also is the 7976's, at 36 inches. Are passageways and doors between the storage area and computer room wide enough? Is there enough room to maneuver the equipment around bends in the hallway?

With the storage area and path to the computer room inspected, you are ready to enter the computer room (or proposed computer room) itself.

THE COMPUTER ROOM

There are three major tasks in the computer room: electrical and physical; environmental; and miscellaneous.

ELECTRICAL/PHYSICAL SPECS AND RECOMMENDATIONS

The electrical and physical tasks are considered together because they are invariably intertwined on the job. A discussion of power leads to a discussion of wiring, which leads to outlets, leading to grounding, leading back to wiring, then to power, and around again. Many CEs find this the most demanding part of site prep. You have to educate the customer, who may know little about AC electricity; and at the same time develop a working relationship with the electrician.

If you don't know the electrician, find out as soon as possible whether he or she has previously done any computer room wiring. That will give you an idea how much time you may have to spend with him/her.

At XYZ Co., you start by explaining that the computer room will need 208V, three-phase power for the SPU. "No problem", says the electrician, "we've got a 208 panel right down the hall at the copy machine. It uses lots of juice, too". You invite him to look over the Series 68B specs. You see that input voltage must be kept between 177 and 229V. Frequency must stay between 57 and 63 Hz. Harmonic content must be kept within plus or minus five percent. Line conducted transients ("noise") must not exceed 1000 volts peak with a 50 percent duration of 100 microseconds and a 100 nanosecond rise time; or 1000 volts peak with a 10 microsecond 50 percent duration and a 1.5 microsecond rise time. Reaching for your test equipment, you ask, "Could you see if anybody has some copying to do on that machine, while we take a few measurements?"

The electrician is right; the copier uses lots of juice. You find the wall power has borderline amplitude even when the copier is off; when it's on, line voltage frequently sags below 177. Additionally, you measure noise spikes over 1000 volts peak. At least two recommended specs are not being met.

Appendix C, Dirty Power and Solutions, is a detailed analysis of "dirty" power and devices used to clean it. The following Paragraph, How Clean Power Gets Dirty, summarizes the problem.

How Clean Power Gets Dirty

Start with a perfect, clean AC sine wave as it leaves the power company. If it arrived at the user's computer in the same condition, we'd all have fewer problems. But it has to travel through wires, where it is vulnerable to all sorts of interference, fluctuations, and noise, including: sags, surges, brownouts, blackouts, thunderstorms, lightning, auto ignition sparking, radio frequency transmissions, and more. And that's not to even mention the impedance of the wires themselves. If that isn't enough, the sine wave gets fed into transformers and stepped up to hundreds of thousands of volts, then stuffed through more transformers and stepped back down to 415, 380, 240, 120, or whatever.

Finally the sine wave reaches the user's building. But before the wave can reach the computer, it has to contend with noisy neighbors like motors, fluorescent lights, dimmer switches, copy machines, pulse-controlled clocks, vending machines, arc welders, vacuum cleaners, floor polishers, ovens, oil burners, stamping machines, automatic coffee makers, hair dryers, and electric razors. And then people get upset when the wave doesn't finish this journey with the same clean lines it had when it left home.

Sorry, sine wave, but you are worthless to a computer unless you can keep your amplitude, frequency, noise level, and shape within certain boundaries. "Specs", we call them. Computers need clean power. If you can't keep clean on your own, we'll make some helpful suggestions.

Dedicated Ground and 'Isolated' Receptacles

Your first helpful suggestion to the customer will probably be that he or she install computer system wiring with a dedicated ground wire and "Isolated Ground" (IG) receptacles. The words "dedicated" and "isolated" are often accompanied by other words, like "uncontaminated, clean, pure, noise free, quiet, and unbroken". All these words are intended to convey one idea: the ground should form a separate, uninterrupted path from the computer to its power source, and from the power source back to the "building service entrance ground".

The "building service entrance ground", in turn, is ultimately tied to earth -- the physical earth, where the worms live. The words "building service entrance ground" have been enclosed in quotes to emphasize the fact that the computer system's ground connection does not have to actually be at the building service entrance. The National Electric Code (NEC), in Articles 250-81 and -83, specifies that the building service entrance ground can be:

- (a) a metal underground water pipe;
- (b) the metal frame of the building;
- (c) a concrete-encased electrode;
- (d) a ground ring; or
- (e) other acceptable "made" electrodes. (Who decides what an "acceptable 'made' electrode" is? That's right -- the local electrical inspector.)

Additionally, if the computer system is powered by a separately-derived power source (a "line conditioner", for example), the NEC, in Article 250-26(c), specifies that the ground connection for that source can be:

- (a) the nearest effectively-grounded structure;
- (b) the nearest available effectively-grounded metal water pipe; or
- (c) any of the ground sources listed in Articles 250-81 and 250-83, above.

In other words, it is NOT necessary to run a special computer system ground wire all the way back to the building service entrance, if one of these listed substitutes is available. In fact, if the computer is on the 20th floor of a high-rise building, there is no point even suggesting to the customer that she run a ground wire all the way down to the building service entrance, because she's not going to do it.

Figures 3-1A, B, and C illustrate these principles. They also illustrate the application of an extra safety ground wire called "G2". ("G1" in the figures is the standard, "dedicated" ground wire.)

"G2" is an extra safety ground wire required by the NEC and the Canadian Electrical Code (CEC) in situations where conduit is not trusted as a safety ground. G2 is required at sites:

- (a) - where flexible or liquidtight conduit longer than six feet is used in conjunction with Isolated Ground (IG) receptacles;
- (b) - which are potentially hazardous, such as those where gas or vapor is present, or those where conduit is subject to corrosion, ground heaving, or other physical damage; or
- (c) - any other situation where the local building/electrical inspector requires it for safety reasons.

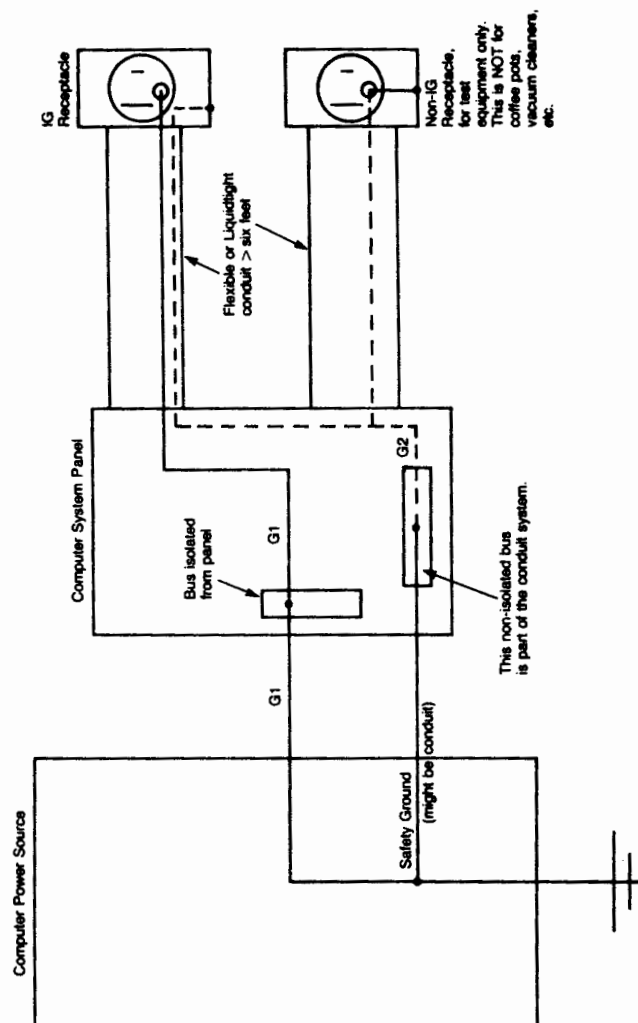


Figure 3-1A. Grounding HP Computers,
No Separately-Derived Power Source

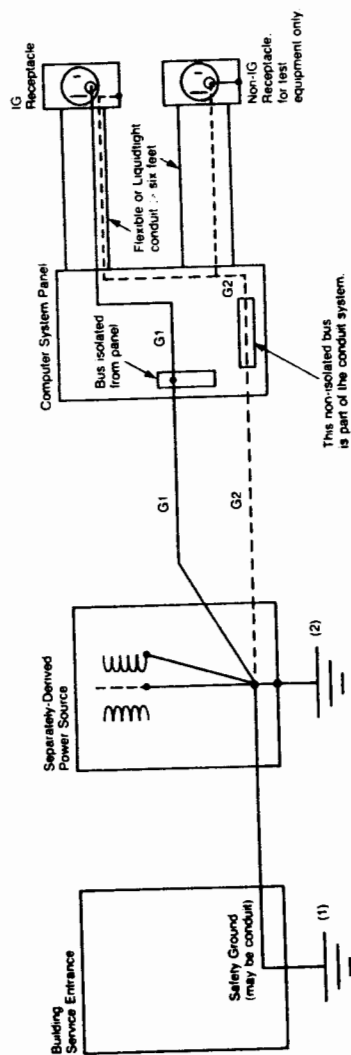
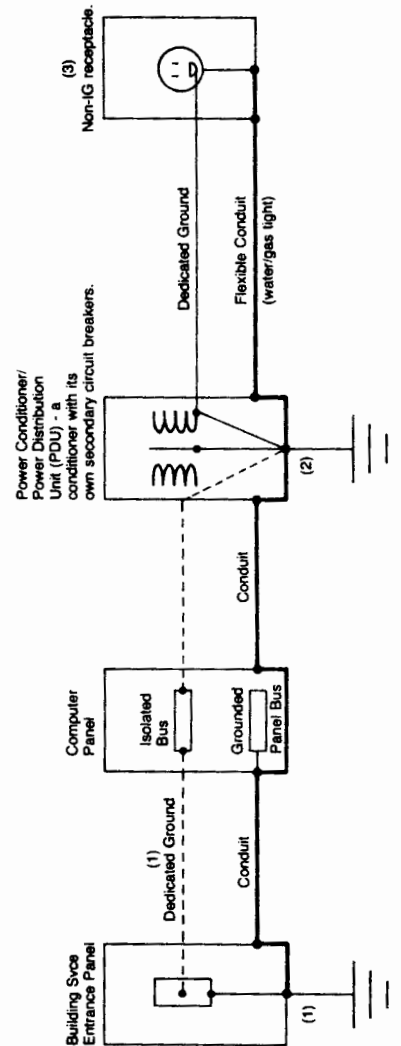


Figure 3-1B. Grounding HP Computers From A Separately-Derived Power Source FEEDING the Computer System Panel

- Notes: (1) Building Service Entrance ground can be: (a) a metal underground water pipe; (b) the metal frame of the building; (c) a concrete-encased electrode; (d) a ground ring; or (e) other acceptable "made" electrodes. Reference: NEC 250-81 and -83.
- (2) The ground for the separately-derived power source can be: (a) the nearest available effectively-grounded structure; (b) the nearest available effectively-grounded metal water pipe; or (c) any of the ground sources listed in Note 1. Reference: NEC 250-26(c).



Notes: (1) Building Service Entrance ground can be: (a) a metal underground water pipe; (b) the metal frame of the building; (c) a concrete-encased electrode; (d) a ground ring; or (e) other acceptable "made" electrodes. Reference: NEC 250-81 and -83. If the computer panel is an already-existing, non-dedicated sub-panel, then the dashed-line ground is not required (the ground point is as described in Note 2).

(2) The ground for the separately-derived power source can be: (a) the nearest available effectively-grounded structure; (b) the nearest available effectively-grounded metal water pipe; or (c) any of the ground sources listed in Note 1. Reference: NEC 250-26(c).

(3) IG receptacle required if distribution is via hard conduit.

Figure 3-1C. Grounding HP Computers From A Separately-Derived Power Source FED FROM the Computer System Panel

Isolated Ground (IG) receptacles contain insulation barriers that keep the computer's ground wire from contacting the receptacle's mounting strap. This prevents contact with the conduit ground. See Figure 3-2.

Trouble and the Word 'Isolated'

The word "isolated"--as in "Isolated Ground Receptacle", for example-- has caused much confusion in the past. Better that the receptacles had been named "Dedicated Ground Receptacles". Unfortunately, electricians know them by the name "Isolated Ground Recepts, IGs", and the HP CE must be able to speak electricians' language. The CE, however, must know the potential danger lurking in the word.

Look again at Figure 3-1B. Focus on the block labeled Separately-Derived Power Source. Notice that the insulation shield between the transformer primary and secondary, the secondary itself, the G1 wire, AND the G2 wire, are ALL TIED TOGETHER AT THE CASE of the Separately-Derived Power Source, and that point IS TIED BACK TO THE BUILDING SERVICE ENTRANCE SAFETY (EARTH) GROUND.

Previous misunderstandings have lead some customers to install the earth ground at the separately-derived power source in a literally "isolated" fashion. That is, they have strung the power source ground out the window to a ground rod in the earth below -- and have not bonded that rod to the building service entrance ground. In other words, on the left side of Figure 3-1B, they have broken the connection between the building service entrance ground and the ground point at the separately-derived power source. The conductivity of the earth itself is being relied upon to provide the return path to the building service entrance ground point. THIS IS UNSAFE; DON'T DO IT!

When talking to electricians, you will have no choice but to refer to "IG" receptacles as IG receptacles. But when talking to customers about ground wires, it is suggested that you purge the word "isolated" from your vocabulary. Use the word "dedicated" instead.

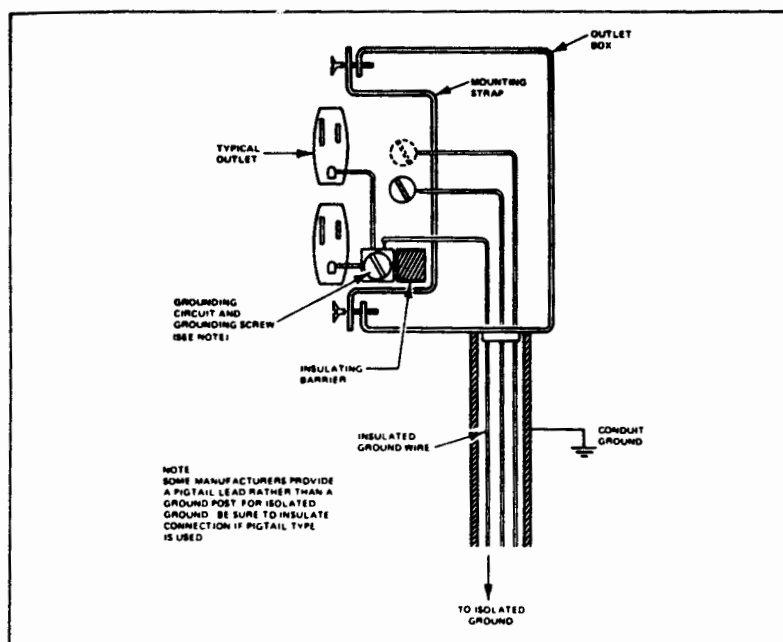


Figure 3-2. Isolated Ground Receptacle

More Help May Be Needed

HP suggests dedicated ground wires and "isolated" receptacles because in many cases they have made customer's power line problems disappear. In many cases . . . but not always. Even with these precautions, there may still be power problems. The customer must be prepared for that possibility, and may have to consider a line treatment device. Depending on the approach that works best for you, you may want to (look ahead to Section 4 and) discuss the various types of line treatment devices with the customer now. Either way, you have more testing to do before deciding whether you think a line treatment device would be helpful at XYZ Co.

To review XYZ's situation, you have demonstrated that power to the computer room does not meet HP's recommended specs. You've told them that other customers have solved similar problems by installing dedicated ground wiring and receptacles, and they've agreed to it. You've explained that this may not be a complete solution; they may still have to consider a line treatment device.

Next, you explain that you want to connect a power monitor as close as possible to the power source that will supply the computer. Hopefully you can leave it connected several days, including over a weekend. That way, you'll catch the Friday afternoon power surges when usage drops, and Monday morning sags when usage jumps.

WARNING

Any time you leave a power cabinet open (for example, when you are monitoring power), you should: (a) place a guard such as a stanchion or marking cone in front of it; and (b) post warning signs reading "DANGER: HIGH VOLTAGE" on either side of it. In the U.S., this is a requirement of the Occupational Safety and Health Act (OSHA); similar practices should be followed in accordance with regulations in other countries.

Dedicated Power Panels

A question that often arises when discussing computer room wiring is whether to install a power panel dedicated to the room. If asked, encourage the customer to do so; it makes it easier to keep other equipment off the computer system line.

Additionally, in the U.S., Section 645-3 of the National Electric Code (NEC) reads, "A disconnecting means shall be provided to disconnect the power to all electronic equipment in the computer room. This disconnecting means shall be controlled from locations readily accessible to the operator at the principal exit doors."

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There shall also be a similar disconnecting means to disconnect the air conditioning system serving this area."

A dedicated power panel is an obviously logical place to locate such a "disconnecting means". If the customer's electrician has not previously wired computer rooms, he may not be aware of this NEC Section, and you should call it to his attention. Refer to Appendix D for other NEC excerpts.

Wire Sizes

As a matter of reference, the following list shows the maximum allowable current, in amperes, for American Wire Gauge (AWG) copper wire sizes. Electricians already know this information, but you may occasionally find it handy to have at hand anyway.

AWG Wire Size	Max Current, Amperes
12	20
10	30
8	40
6	55
4	70
3	80
2	95
1	110
0	125
00	145
000	165
0000	195
250	215
300	240
350	260
400	280

In Europe, wires are sized by square millimeters, rather than AWG. European electricians commonly find copper wire size by dividing the current load in amperes, by five. For example, using a 25A load: 25 divided by five calls for a wire size of five square millimeters.

In sites where there is a long distance between the power panel and computer, experienced electricians often guard against voltage drops by installing one size larger wire for every 31 metres (100 feet) between the panel and the equipment.

CBEMA Three-Phase Wiring Recommendation

The use of switching power supplies in three-phase computer systems has had an unforeseen affect on attempts at load balancing. As a result, the Computer and Business Equipment Manufacturers Association (CBEMA) has recommended to its members that the Neutral wire in three-phase systems be sized to carry 1.732 times the current in the phase wires (1.732 is the square root of 3). If you

are asked if Hewlett-Packard "recommends" this, you may want to show the questioner the full text of the CBEMA statement. It reads:

"The advent of the new technology power supplies used in modern computers and office machines provides significant reductions of weight and volume and major increases in efficiency. This technology requires lower input power and less cooling. With all of these advantages there are some concerns which must be addressed.

"The new technology switching supply is a non-linear load which means that the voltage and current wave shapes are not identical. (The load draws power from the line for only a portion of the cycle). In the home, some examples of linear loads are toasters and electric ranges, while the television and microwave ovens are examples of non-linear loads.

"The non-linear loads generate harmonic currents. These harmonic currents may cause overheating and circuit breaker trips in the power distribution and electrical service systems.

"A three (3) phase system using many single-phase, non-linear loads will have increased Neutral currents which cannot be eliminated by phase balancing (emphasis added by HP). These combined Neutral currents can exceed the phase current by a maximum factor of the square root of three, 1.732. An increase in the number of non-linear loads may cause unexplained tripping of the circuit breakers and overloading of the Neutral conductor which is not protected by a circuit breaker. Non-linear load currents cannot be accurately measured without proper test equipment (True RMS measuring equipment).

"Some methods of minimizing the effects of non-linear loads are:

- "1. Ensure that the three-phase transformer is rated and protected on the basis of both input and output current.
- "2. Size the three-phase common Neutral to carry 1.732 times the phase current. (Emphasis added.)
- "3. Maintain close liaison with the data processing or office machine manufacturer on new installation designs and when changing existing installations."

Employee Cautions, Electrical

You should advise the customer that once the isolated computer system wiring is installed, not to contaminate it by connecting appliances that make large current demands and/or induce noise. Janitors especially should be cautioned against connecting vacuum cleaners or floor polishers. Another notorious offender is the automatic coffee maker; the computer system manager should advise the staff to connect it somewhere else.

ENVIRONMENTAL SPECS AND RECOMMENDATIONS

Environmental topics can be grouped into temperature and humidity control; Electromagnetic Interference; Electrostatic Discharge; and airborne contamination. Let's take them in that order.

TEMPERATURE AND HUMIDITY CONTROL

The time has come to use XYZ's system heat generation total, which you calculated in Table 2-1. You tell XYZ, "Your HP Computer System will generate approximately 24,000 BTUs/Hr of heat. If that was your only consideration, you could buy an air conditioner today. But that's not your only consideration". Other considerations include:

- any other heat-generating equipment (line treatment devices, for instance) in the room;
- the people who will work there;
- the type, number, and location of the lights;
- the placement of partitions (if any);
- the amount of insulation (if any) in the walls, ceiling, and floor;
- the construction of the walls;
- what the temperature and humidity are outside the room, and how much come-and-go traffic there will be;
- the advisability of building vapor barriers into the walls, ceilings, or floors--or placing "wallpaper" vapor barriers on the walls;
- whether a raised floor is planned;
- whether any outside-wall windows face the sun, and if so, how many hours a day;
- what kind of drapes, shades, curtains, or blinds those windows will have;
- possible future expansion of the computer system or any other heat-generating equipment in the room;
- whether the site has dust problems;
- whether a certain air pressure should be maintained in the room;

- whether the floors, ceiling, and walls should be sealed, and if so, with what;
- whether the air conditioner will operate 24 hours a day, or be powered off at nights and on weekends (It this is the case, advise them to shut down the computer system each time they take the air conditioner down);
- and any number of other architectural, physical or environment topics that may be considered before an air conditioning system goes in.

You should call these things to the customer's attention, but the decision about what size air conditioner to install is his. He may very well need to hire an air conditioning consultant to help with this, especially if this is the first time he has been through it. In any case, Hewlett-Packard cannot provide a "You need an X-ton air conditioner" service. What we can do is tell the customer how much heat his HP equipment will generate, and try to convince him to consult qualified help weighing all the other considerations involved in selecting and sizing an air conditioner.

If the customer is inexperienced with air conditioning, you should ensure she at least understands the basic difference between process cooling systems (also known as "sensible" systems) and comfort systems (also called "latent") before seeking a consultant. Process air conditioners cool the air without taking moisture from it. Thus they are much preferred for computer rooms, as the heat generated by the computer itself is dry and takes moisture from the air.

Comfort systems are intended for homes; they remove moisture from the air as well as cool it. In some cases where comfort systems have been installed in computer rooms, the customer subsequently had to add a humidifier to restore the moisture removed by the air conditioner. When that happens, the humidifier puts moisture in the air; the comfort conditioner takes it back out; the humidifier puts it back in; the conditioner takes it back out; etc. The customer learns about this tug of war when the electricity bill arrives.

Checking Appendix Z for recommended operating temperature and humidity specs, you find:

Recommended operating temperature:

Series 68B: 20 to 25.5 degrees C, 68 to 78 degrees F.

2563A: 10 to 50 degrees C, 50 to 122 degrees F.

7976: (None listed.)

7935: 20 to 30 degrees C, 68 to 86 degrees F.

Thus, the Series 68B sets the "system" (weakest link) recommended operating temperature spec, at 20 to 25.5 degrees C, 68 to 78 degrees F.

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Recommended operating humidity, non-condensing:

Series 68B: 40 to 60 percent.

2563A: 25 to 85 percent (the spec sheet notes that the paper may have a tighter spec).

7976: (None listed.)

7935: (None listed.)

Again the Series 68B sets the "system" recommended operating humidity spec, at 40 to 60 percent.

XYZ Co. now calls in an air conditioning consultant and says, "I need a process type air conditioner for my computer room. I need to keep the temperature between 20 and 25.5 degrees C and the humidity between 40 and 60 percent. The computer system itself will generate approximately 24,000 BTUs/Hr of heat. It will run 24 hours a day, six days a week. Four people will work in the room. What other information do you need?"

ELECTROMAGNETIC INTERFERENCE, SUSCEPTIBILITY

Electromagnetic Interference (EMI, commonly but not quite properly equated with its subset "Radio Frequency Interference"), is being found more and more often in urban areas. In some cases its source is very hard to isolate, because EMI is often intermittent and unpredictable. Thus, avoiding it often amounts to invoking "magic", e.g., moving equipment around the room until the interference disappears.

Permanent solutions to EMI problems have ranged from relocating computer systems within buildings to covering windows with metal screens. In extreme cases where systems couldn't be moved, computer rooms have been completely shielded.

The incidence of EMI varies. As stated, CEs in many urban areas report increasingly common occurrences. In other areas, CEs rarely encounter the problem. The decision whether EMI should be tested for on every site prep call, on some, or only in areas known to be hot, should be made locally.

Checking Appendix Z for EMI susceptibility specs for XYZ's components, you find (unit is volts per metre over a frequency range of 14 kHz to 1 GHz):

Series 68B: one-half volt

2563A: one volt

7976: one volt

7935: three volts

Thus the EMI susceptibility spec for XYZ's system is set by the Series 68B, at one-half volt per metre, over the 14 kHz to 1 GHz frequency range.

The Product Support Division (PRSD) has compiled a list of EMI consultants you may give to customers with problem sites. You can help both customer and consultant by convincing the customer of the need to keep detailed records of the occurrences, especially the time. Often, what seem like random occurrences prove to be the watchman coming along and keying his hand-held transeiver ("walkie-talkie") every four hours; or the police using a radar gun outside the computer room during certain hours; or (believe it or not) a radar-laden ship sailing through the harbor once a month. You will never know, in any case, unless good records of the failures are kept.

One key criterion in compiling the consultants' list was that each one must supply his own equipment; he must not require the customer to provide any equipment or material. When offering this (or any other) list of consultants to a customer, be sure to point out that HP is providing it as a service only; the customer is not obligated to choose from the list, nor should he assume no other consultants are available. Refer to Appendix E for the list of consultants and the criteria used in compiling it.

Employee Cautions, EMI

Ask if any XYZ employees use hand-held transceivers or cordless telephones. If so, they should be warned not to use them near the computer room. They have been known to emit enough EMI to crash disc drives. A warning sign outside the computer room would help. Also suggest that if the night shift computer operator keeps in touch with the world via his portable Citizen's Band Radio, he be advised to stay off the air while in or near the computer room.

ELECTROMAGNETIC INTERFERENCE, EMISSIONS

As you know, site prep duties usually involve the electrical and environmental conditions HP computers are susceptible to. I.e., you

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must educate the customer so the site doesn't adversely affect the computer. But there is a second question: are there any consequences to the site from computer emissions? I.e., does the computer affect the site? This Paragraph describes the two largest EMI emission standards agencies with authority where HP computers are sold.

All HP Computer Groups products introduced since November 1, 1983, meet U.S. Federal Communications Commission (FCC) Class A limits. Additionally, products defined by the FCC as Class B devices meet FCC Class B limits and are certified by the FCC. The FCC is the EMI regulatory authority in the U.S. FCC Class A devices are those used only in industrial environments; Class B devices are those that can be used in residential environments.

The Verband Deutscher Elektrotechniker (VDE) is a West German test agency that sets EMI standards followed in Europe. VDE Level A devices cannot be sold in residential or sensitive areas. Level B devices have no sales restrictions. All HP Computer Groups products introduced since November 1, 1983, meet VDE Level B limits.

New HP products are not sold without meeting FCC and VDE standards, unless the manufacturing division obtains a waiver from the Computer Groups Executive Vice President. Such waivers are rare. Even products with waivers must meet FCC Class A and VDE Level A limits to be legally marketed in the U.S. and Europe. The only exceptions are: (a) - electronic control devices used in industrial plants (they are exempt from FCC, but not VDE, regulations); and (b) - test and medical equipment, which are exempt from both FCC and VDE regulations.

All Computer Groups products and systems introduced before November 1, 1983, have been tested to verify that they comply with FCC Class A limits at the system level. Products and configurations which do not, are no longer sold.

If you have emissions questions about a particular product or system, consult the product documentation, or contact the Product Regulations Department of the manufacturing division.

ELECTROSTATIC DISCHARGE

Electrostatic Discharge (ESD) occurs when two dissimilar non-conductors come into contact, then are quickly separated. A classic example is a human being wearing shoes walking across a carpet.

The potential for ESD problems increases when humidity is very low. This won't be a concern if the site meets the weakest link recommended spec as described in the preceding Temperature and Humidity Paragraph.

Checking Appendix Z for recommended ESD specs for XYZ Co.'s system components, you find:

Series 68B: 15 kV
2563A: 15 kV
7976: 10 kV
7935: 15 kV

Thus XYZ's system recommended spec for ESD is set by the 7976, at 10 kV.

Invariably, a discussion of ESD leads directly to floor covering. This usually means carpeting.

Carpeting

The policy on this subject is as follows: HP strongly discourages carpeting within six metres (20 feet) of the computer system. If that advice is not followed, we urge the customer to place anti static mats (e.g. HP 92176) or static control mats (e.g. HP 92175) where people must walk across them before they can touch the computer. Otherwise, any floor covering within six metres (20 feet) of the computer is subject to a recommended maximum resistivity spec of 1000 Megaohms per "square". (The size of a "square" depends on the size of the electrode on your HP4329A High Resistance Meter with 16008A Resistivity Cell.)

To get it on the record: HP DOES NOT have a specification prohibiting carpeting. We "strongly discourage" it because it contributes to the buildup of ESD, and because it sheds lint and traps dust, dirt, tobacco smoke and ashes, and other contamination. Remember, the carpet itself is not the enemy; it just lays there and gets stepped on. The enemy is the ESD and contamination.

NOTE

If the customer buys anti static mats or static control mats, be sure she understands that:
(a)--To be effective, the mats MUST BE GROUNDED;
and (b)--They must be placed where people must step on them before touching the computer.

Anti Static Sprays

Customers who have carpeting (and intend to keep it) may ask about anti static sprays claimed to be effective on carpets. In some cases these sprays have been blamed for clogging filters and gumming electronics when drawn into computer cabinets. Please avoid suggesting the use of these sprays.

NOTE

HP sells an ACL Co. anti static spray called "Staticide" through the Computer Users Catalog. It is intended for hard surfaces, however, not carpets.

Triboelectric Series

Figure 3-3 shows a triboelectric series comparing ESD potentials when shoe soles come in contact with common carpet fabrics. "Triboelectric" is the name for the process of gaining and losing electrons when two dissimilar materials come into contact and are then quickly separated. The relative static potential between a carpet fabric and a shoe sole is determined by the distance between them in the figure. Thus, combinations with high static potential include wool carpet and shoes with rubber soles, or polypropylene carpet and shoes with chrome-tanned leather soles. Combinations with low static potential include polyester carpet and shoes with Neolite soles, or acrylic carpet and shoes with rubber soles.

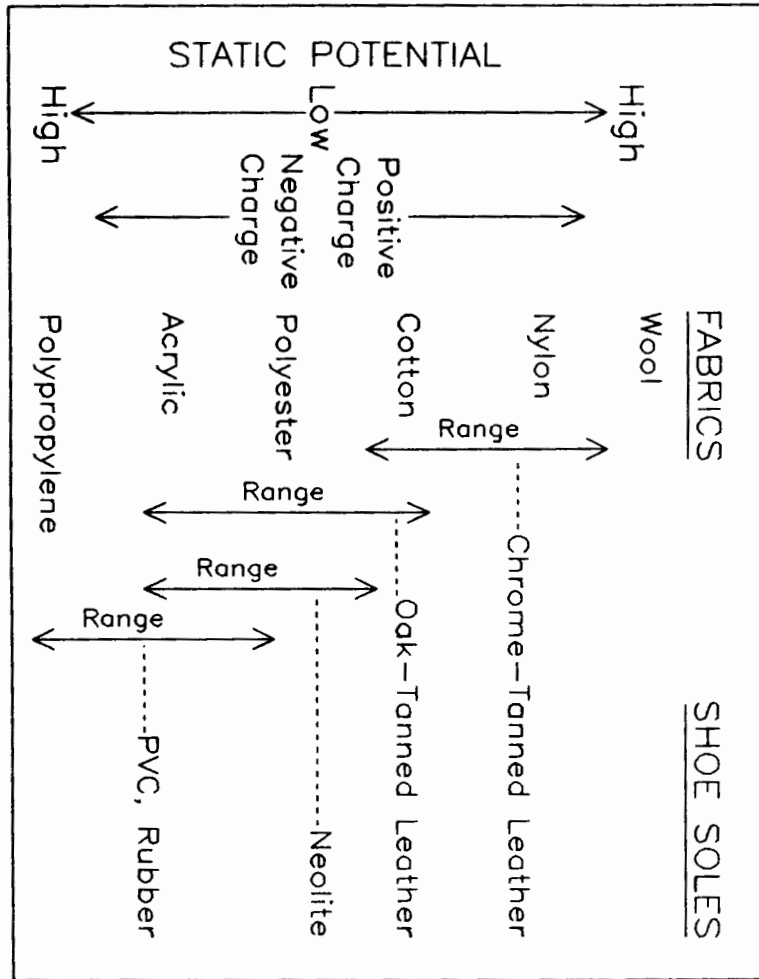


Figure 3-3. Triboelectric Series, Carpet Vs. Shoe Soles

Raised Floors and ESD

In the Temperature and Humidity Paragraph, it was noted that one decision the customer must make when picking an air conditioner is whether the computer room will have a raised floor. The safety and aesthetic advantages of a raised floor are obvious, but ESD potential must be considered in its construction.

Raised floors are usually supported by pedestals connected by stringers. The floor panels often have laminate tile surfaces, and steel frames. The customer should be urged to paint the pedestals, stringers, and frames with conductive paint to ensure that the floor serves as a uniform electrical "plate". This "plate" should be at the same voltage potential as the computer system cabinets, i.e., at zero volts, ground. If any pads or cushions are used between the panels and the pedestals, they should be conductive.

In many cases where raised floors are used, removable panels are included to allow electrical service outlets below the floor. In this case, the outlets should be connected to grommets that are fastened to the panels. See Figure 3-4. Additionally, the electrical service box should be connected by conduit back to the building safety ground. See Figure 3-5. This provides two discharge paths for any ESD potential that builds up on the floor.

However, in extreme cases (e.g., when ESD is already a threat because humidity is hard to control), even these measures may not be sufficient. In such a case, suggest that the customer install actual, physical metal plates (as opposed to the "plate" referred to in the preceding paragraph) below the access floor. This plate should be bonded to the building ground via a distribution panel, as shown in Figure 3-6. Figures 3-4, 3-5, and 3-6 are from the DONN Corp.

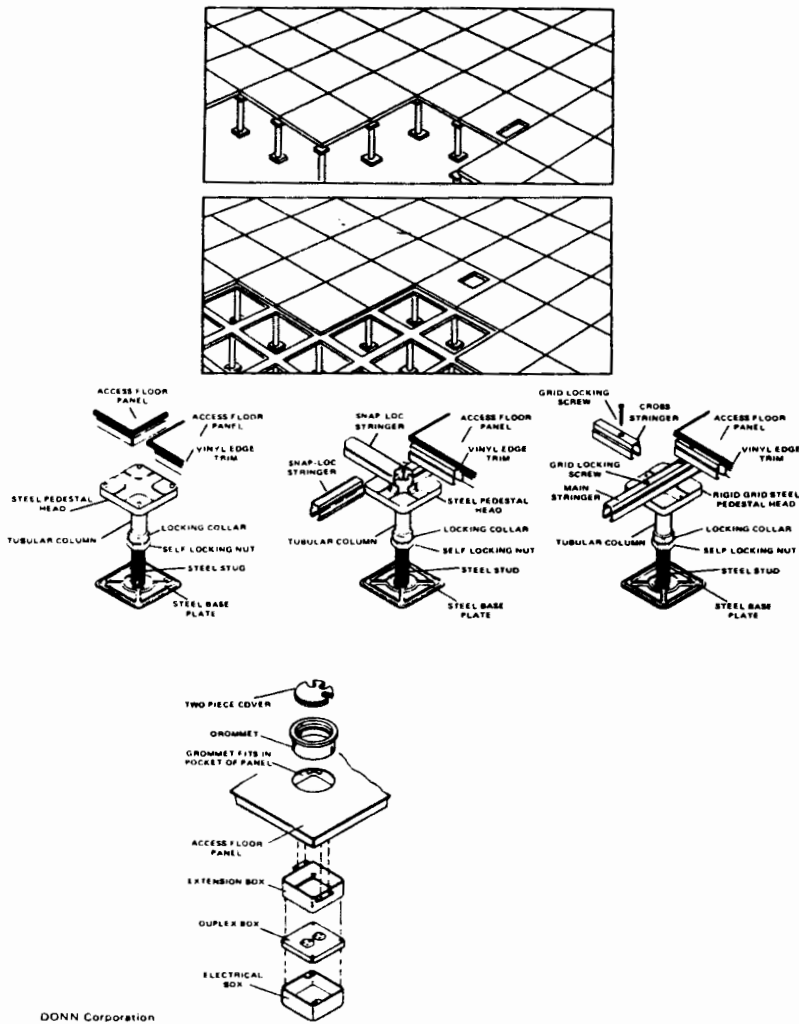


Figure 3-4. Raised Floor with Service Outlet and Grommet

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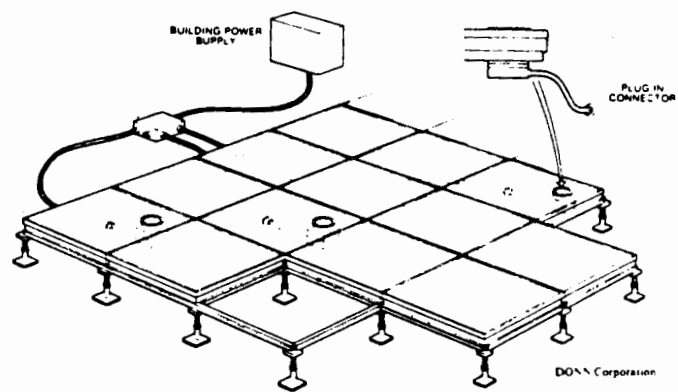


Figure 3-5. Raised Floor with Grounded Service Outlets

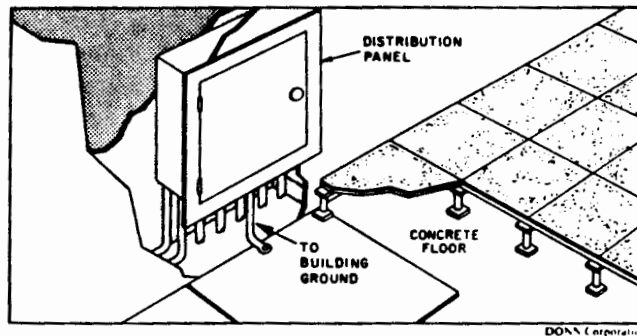


Figure 3-6. Raised Floor with Grounding Plate

AIRBORNE CONTAMINATION

Airborne contamination includes two categories: a - particulates; and b - copper corrosion. H-P Corporate Standards, as published March 1, 1986 in Section 768 of the Environmental Tests Manual, classify sites by their particulate and corrosion levels as follows.

In terms of particulates: a site with 55 micrograms per cubic metre or less is classified as a "business" site; one with 56 to 200 micrograms per cubic metre is classified as an "industrial" site. Anything higher is called "severe". In any case where a "severe" condition is found, H-P reserves the right not to supply the customer with a CSSA.

In terms of copper corrosion: a site with 1200 Angstroms per year or less is classified "business"; one with 1201 to 7500 Angstroms per year is classified "industrial"; anything higher is called "severe". In any case where a "severe" condition is found, H-P reserves the right not to supply the customer with a CSSA.

Section 768 uses the following language to describe the terms "business level" and "industrial level":

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"Business Level. This level is typical of business offices and work places in urban areas. These sites will rarely cause corrosion or particle related problems. Business offices on or near industrial complexes may be part of this class if care is taken to isolate the pollutant sources from the hardware.

"Industrial Level. This level is typical of indoor industrial facilities or offices with local internal or external pollutant sources. These sites can cause significant corrosion related reliability problems. Pulp, paper, petroleum, chemical, and metal processing complexes are most suspect. Computer room facilities on these sites may be very vulnerable to corrosion if air handling and purification systems fail. Proper hardware design and choice of materials can reduce reliability problems significantly in these environments."

In cases where airborne contamination is known or suspected, contact your regional environmental engineer; he has the tools and training to help you make appropriate tests. Meanwhile, the following paragraphs contain information you can give the customer.

Particulates

Airborne particulates can damage computer components by interfering with moving parts and by deposition on sensitive material. By interfering with moving parts, particles can cause abrasion, head crashes, and connector intermittents. Particle deposition can cause:

a -- Shorts, if conductive paths are formed. Many kinds of dust particles are not electrically conductive themselves, but can absorb much moisture in areas with high humidity.

b -- Increased component failures, if particle buildup results in a thermally insulating layer. This process accelerates on sites with oil mists.

c -- Corrosive failures or contact intermittents, caused by the intrinsic composition of the particle itself, or the absorption of water vapor and gas by the particle.

Regardless of whether a given location is a "business" or "industrial" site, HP believes that operation over the 55 microgram per cubic metre level will cause:

a -- 50 percent shorter life of filters in the system;

b -- possible thermal breakdown in one to three years; and

c -- intermittents in contact switches within four or five years.

Computer operation at levels above 200 micrograms per cubic metre would: in addition to negating the customer's CSSA, would:

- a -- reduce filter life to 20 percent of normal;
- b -- cause thermal breakdown in six months to a year; and
- c -- cause intermittents in switches in one to three years.

You can offer the customer the following suggestions about designing or improving a computer room to minimize the influx of airborne particles:

- a -- A tightly-sealed room, pressurized to positive .08 inch of water relative to adjacent areas should reduce the influx of dust through doors, vents, windows, and air leaks. If this is done, it is advisable to build in an alarm that sounds when the pressure drops below the intended level.
- b -- Avoid drawing make-up air from anywhere particles are known or suspected.
- c -- The air-handling system should supply a minimum of two volume exchanges per hour.
- d -- Ensure that maintenance of the air handling system and replacement of filters is performed at the intervals suggested by the manufacturer.
- e -- The computer should be shut down any time the air handling system fails.

In cases where clean make-up air is not available, a special air treatment system may be required. Sometimes, replacing standard filters with High Efficiency Particulate Air (HEPA) filters will bring particle levels within a tolerable range.

Corrosion

Corrosion is the deterioration of a material because of a chemical reaction with its environment. The white buildup on auto battery terminals is a common example. In electronic systems, the most noticed form of corrosion is a thin film on electrical contacts, usually resulting in intermittent or open contacts.

Circuits can also fail because of corrosion-caused leakage across dielectric materials, IC sockets, and other insulators. In some cases, corrosion can cause a direct short between traces on a circuit board. In cases where high humidity exists, electrolysis between components at different voltage levels can destroy mounting hardware to the point that components actually fall off boards.

Corrosion is commonly caused by minute quantities of some gases in the presence of water. Some corrosive gases are chlorine, hydrogen sulfide, ammonia, hydrocarbons, sulfur dioxide, and nitrogen oxide.

The Site Planning Visit

Chlorine is commonly found in cleaning solvents, metal processing plants, and trash dumps. Hydrogen sulfide is found at petroleum plants, wood pulp processing, and sewage treatment plants. Ammonia is found in cleaning solvents, blueprint machines, pulp and paper mills, sewage treatment plants, and fertilizer processing plants.

Hydrocarbons are found in petroleum manufacture, automobile emissions, and industrial sources. Sulfur dioxides are the result of most combustion processes, including coal, wood, petroleum, auto emissions, and ore smelting. Nitrogen oxide is commonly found in the chemical industry, auto emissions, and petroleum combustion.

MISCELLANEOUS INFORMATION

The following paragraphs cover such things as fire protection, lighting, and computer room maintenance, topics that are not covered by HP specifications. This does not mean, however, that they are unimportant to the customer. The subject of fire protection, for instance, is obviously important to everyone. The subjects are gathered as miscellaneous because HP does not spec them; nevertheless they appear in one or more manufacturing division customer site prep manuals. If asked about any of this material, make it clear it is introductory information only.

Fire Protection

In the U.S., the National Fire Protection Association (NFPA), Batterymarch Park, Quincy, MA., 02269, is a recognized authority on fire protection information. Customers who ask for specific information on fire protection systems should be referred there, and to the local fire inspector, and to their fire insurance carrier.

Three major types of fire protection equipment are available for computer rooms: water sprinklers, halogenated gas, and carbon dioxide. Water sprinklers are generally believed to be an effective means for containing a fire; however, the possibility of water damage to electronic equipment is obvious.

Halogenated gas extinguishes fires by reacting directly to the burning material and the temperature of the fire. This is believed the most effective system against electrical fires, and least damaging to electronic equipment. A concentration of five percent Halon 1301 produces extinguishing effects in about 10 seconds.

Carbon dioxide is not a fire-extinguishing agent itself, but has an extinguishing effect by displacing oxygen. This usually takes place in about a minute after discharge, depending on the burning area. Carbon dioxide is most commonly used in portable extinguishers.

Lighting

Should you learn the customer is considering dimmer light switches in the computer room, point out that they are notorious for generating electrical noise and EMI.

You should confirm that the customer doesn't plan to use direct (window) lighting for illumination, because of the heat and glare problems it might cause. Also check that planned lighting will provide sufficient illumination near the walls and in corners, where the HP CE is likely to find himself on service and PM calls.

One manufacturing division's customer site prep manual contains a statement reading, "To properly light the computer area, plan to maintain an average of 50 to 75 foot-candles of total illumination as measured 30 inches above the floor." This is advice only; it is not an HP recommended specification.

Cleaning and Maintenance

Ideas the customer might want to implement in the computer room include:

- a -- Prohibit smoking.
- b -- Limit access to authorized people.
- c -- Use anti-static, lint-free, dust cloths.
- d -- When mopping, use a damp mop, not wet or dry.
- e -- Avoid using steel wool on floors.
- f -- Apply floor polish sparingly.
- g -- Ensure that a regular schedule for replacement of air conditioner filters is maintained according to the manufacturer's instructions.

DETAILED FLOOR PLAN

At this point you will be ready to help the customer develop a detailed floor plan, using the grid sheets included with the manufacturing divisions' customer site prep manuals (or any customized sheets you have developed yourself). By this time, you and the customer have discussed everything that must be considered in the floor plan, with the possible exception of specific pieces of furniture and storage cabinets.

Figure 3-7 shows a sample generic floor plan. You may want to show it to the customer and point out its advantages, including:

The Site Planning Visit

- a -- Room has been allowed in front of the equipment doors for servicing.
- b -- Sound-absorbing partitions have been placed between the system and the three terminal desks.
- c -- The line printer, with paper tray, has been placed away from the processor and disc drives, and close to the door.
- d -- A circuit panel, fire extinguisher, and emergency power switches have been planned for.
- e -- The system console has been placed near the processor, and a telephone is provided for the console operator.
- f -- Shelves and cabinets have been provided for mag tapes and printer paper.

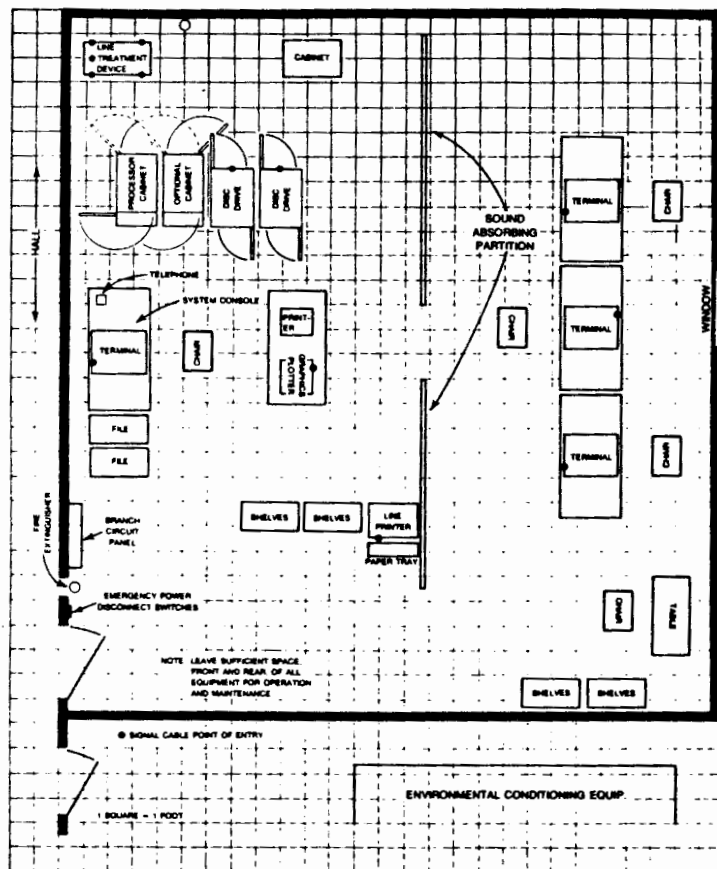


Figure 3-7. Sample Generic Floor Plan

The Site Planning Visit

FOLLOWING UP

Before leaving XYZ Co., make arrangements for your return visit(s), depending on what occurred during the site planning visit. If you installed a power monitor, you will be returning to pick it up in a few days. If dust is present, you will be returning with your Regional Airborne Contamination Engineer to set up particle tests. In any case, you will return for the site survey.

It is a good idea to write the customer a letter after the visit, restating the advisability of any site modifications discussed.

THE SITE SURVEY

SECTION

4

In the site survey, you return to the customer's site to inspect any modifications made since your planning visit, and/or gather data from any test equipment you left in place.

In the example of XYZ Co., you are chiefly interested in the information recorded by the disturbance analyzer ("power monitor"). Assume the monitor establishes that the building power has sag and noise problems. You now advise XYZ Co. to consider a line treatment device.

LINE TREATMENT DEVICES

Figure 4-1 will help you counsel customers about the capabilities, limits, and relative cost of six major line treatment device types. Point out that the figure represents the collected experience and opinions of HP Site Prep CEs, and should be taken as a guideline only. The customer will have to decide which device, if any, he wants. As with air conditioners, HP cannot, and does not, make the customer's decision about a line treatment device. What HP does is tell him how much power his HP equipment will use, and give him a basic education in line treatment devices, so he will be able to discuss them intelligently with vendor reps.

First, let's define the terms in the Problem Column of Figure 4-1. "Noise" means any unwanted or spurious voltage on the line. "Sag" refers to a short term drop in amplitude; "surge" to a short term increase. A "brownout" is a long term sag. A "dropout" is a short term loss of power (the power goes to zero, rather than just sagging). A "blackout" is a long term power loss.

Starting at the top of Figure 4-1, you show XYZ that Uninterruptible Power Sources (UPSs) are the only devices that will protect against all the problems listed, including dropouts and blackouts. Since XYZ is not an airline reservations agency, international bank, or other business that absolutely cannot afford to ever have its system off the air, you might counsel against the expense and noise (audible sound) of UPSs. Motor generators protect against some dropouts but not blackouts. Like UPSs, they are often costly and produce (audible) noise.

Skipping to the bottom of the comparison, you show XYZ that since isolation transformers and spike suppressors do not protect against sags, one of the problems here, they should not be considered. That leaves only line conditioners and voltage regulators. Both are effective against sags; but only line conditioners also protect against (electrical) noise, the second problem here.

The Site Survey

Now another item enters the analysis. XYZ's computer system requires three phase power, and it is the opinion of many experienced HP site prep CEs that only line conditioners perform acceptably in three phase applications. Then, among line conditioners, many experienced HP site prep CEs share the opinion that standard ferroresonants do not perform acceptably in three phase applications. That leaves only tap switchers and magnetic synthesizers for further consideration.

You have done XYZ a valuable service, filtering the crowded field of line treatment devices down to a manageable two types of line conditioners. You might also tell XYZ what choice other HP customers with similar problems have made. "About 80 percent of our customers in the area with power problems like yours have chosen a tap switcher," you might say, making sure XYZ understands that the choice is theirs -- and the choices of which tap switcher and where they buy it, also are theirs.

NOTE

The possibility, however remote, exists that any line treatment device could fail some day. For that reason, many CEs urge customers to install emergency bypass wiring at the same time the treatment device is installed. That way, if the device ever has to be removed for repair or replacement, the system will have some source of power, albeit possibly "dirty". Such a bypass is shown in the illustration of a typical UPS in Appendix C, Figure C-16, but the advice applies to other line treatment devices as well.

EQUIPMENT TYPE	RELATIVE COST AS % OF UPS	ESTIMATED % OF PROBLEMS SOLVED	PROBLEM SOLVED				
			NOISE	SAG/SURGE	BROWNOUT	DROPOUT	BLACKOUT
UPS	100	100	Yes	Yes	Yes	Yes	Yes
Motor Generator	60-90	90-96	Yes	Yes	Yes	Some	No
Line Conditioner	40-50	90	Yes	Yes	Yes	No	No
Voltage Regulator	15	40	No	Yes	Yes	No	No
Isolation Transformer	15	25	50%	No	No	No	No
Spike Suppressor	20	40	80%	No	No	No	No
ESTIMATED RELATIVE PROBLEM FREQUENCY			50%	30%	10%	6%	4%

Figure 4-1. Line Treatment Device Cost/Benefit Comparison

The Site Survey

You are now ready to show XYZ Co. the computer system power consumption value you calculated in Table 2-1. As XYZ prepares to interview line treatment device vendors, be sure to tell them that: (a) they should allow for future computer system growth; and (b) different line treatment devices are most efficient at different loads, so they should expect vendor reps to say things like, "Our conditioner works best at 80 percent load, so you should install a conditioner with (system VA value) divided by 80 percent."

The preceding example taking XYZ Co. through the layers of decisions about line treatment devices, represents what we believe is the opinion of the majority of experienced site prep CEs. The following article supporting that opinion is reprinted from the June 11, 1982 *Support Update*.

Three-Phase Power Conditioner Guidelines

When the HP 3000 Series 64 Computer was introduced, site prep CEs found themselves dealing with three-phase power conditioners for customer sites where the measured power is outside HP specs. Power conditioning needs for the Low Cost Series III, 30, 33, 40, and 44 were simpler since they could all be powered from a single-phase power conditioner with an output in the range of 200 to 240V. With three-phase power for the Series 64 SPU, site prep CEs must learn the loading requirements for three-phase conditioners.

Power conditioners can be classified in three major categories:

- a -- SCR-controlled tap switchers
- b -- Conventional ferroresonant transformers
- c -- Three-phase ferroresonant transformers or datawave synthesizers

Some precautions must be followed when using any of these devices. However, the conventional ferro has unusual characteristics when used in three-phase power systems and subject to a load imbalance greater than 15 percent. Single-phase applications of ferros present no problem. Likewise, SCR-controlled tap switchers and datawave synthesizers present no serious problems when subjected to load imbalances.

The problem is this: All conventional ferros implement a three-phase transformer by connecting, usually in Wye-wired configuration, three single-phase ferroresonant transformers. (This is NOT the case for the so-called datawave synthesizer or three-phase ferro.) Each of these single-phase transformers regulates its output voltage to 120V (120/208V North American system), and only varies it under transient load current changes.

As with all Wye-derived power systems, the line-to-line voltage is developed from the vector sum of two single-phase voltages which are shifted in time by one-third of a cycle, i.e. 120 electrical degrees. See Figure 4-2.

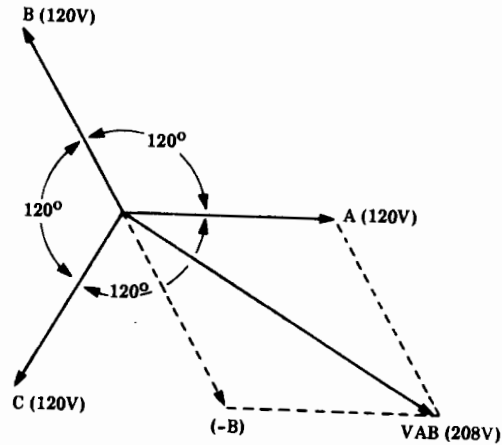


Figure 4-2. Normal Vector Summation

As you see in Figure 4-2, the derivation of the 208V vector (VAB) depends on two things: (a) - each phase voltage must be 120V; and (b) - the angle between the phase voltages must be 120 electrical degrees. One of the often forgotten characteristics of ferro transformers is that there is a phase shift between the input (primary) sine wave and the output (secondary) sine wave, and this phase shift varies with changing load current. This is not a concern in single-phase ferro installations, but it is troublesome when you configure a three-phase system. Let's look at more vector diagrams, but this time with phase angles less than and greater than 120 degrees. See Figures 4-3 and 4-4.

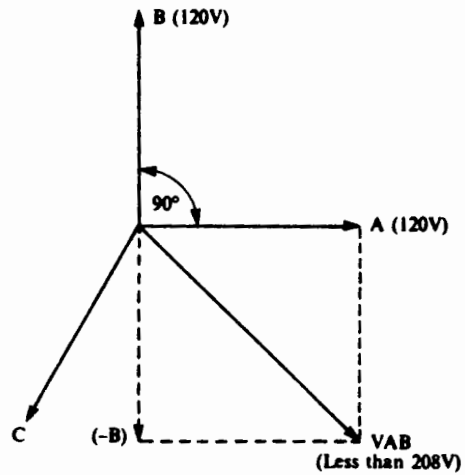


Figure 4-3. Phase Angle Less Than 120 Degrees

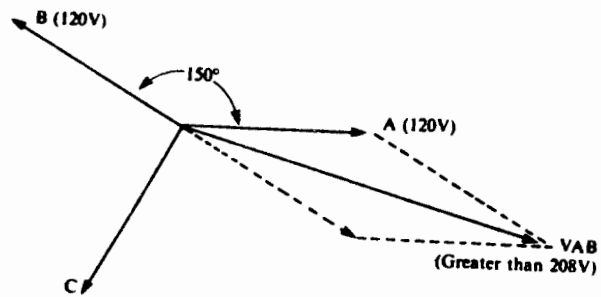


Figure 4-4. Phase Angle Greater Than 120 Degrees

Measurements of the 208V nominal have been taken at sites known to have severe load imbalances. These measurements ranged from 180 to 235V; however, the individual phases all measured 120V. Under those conditions, any equipment requiring 208V could have frequent power supply failures. The way to prevent the 208V from drifting is to require a close balancing of the load on the ferro, as was done on HP 3000 Series II and III Computers with 792X Disc Drives.

The reason this worked on the Series II and III is that the disc drive load current was small (5A), and the only device that cycled on and off regularly was the 7970B/E Mag Tape Unit with a steady-state current of 2.5A. It was possible to achieve a load balance within 15 percent for these systems.

The situation is very different with the Series 64 and its complement of peripherals. First, the 64 draws more than double the current of a Series II or III, and it also has to contend with an unbalanced peripheral load. The 793X Disc Drives are standard North America 208V at 9.3A. The 7976A Mag Tape Unit is a 120V device at 15.8A with a 32A surge for 1.5 seconds during tape loading. Is it possible to sustain a steady load balance within 15 percent with this mixture of devices? NO! When a 2680 LASER Printer is included (24A at 208V) the situation is really difficult.

The Series 64 is not the only place to beware of problems with conventional ferros in three-phase configurations. Watch out for Series 44s with newer peripherals (793X, 7976, 2680) where the customer might choose a three-phase system because of load levels. Also, beware of the multiple-system computer room (several HP systems or a mixture of HP and non-HP systems). Since there is no way to guarantee a day-to-day load balance, trying to use a conventional ferro there would be asking for trouble.

To summarize, here are three rules of thumb:

- a -- Use a conventional ferro in single-phase applications, or with small Series II or III systems.
- b -- Do Not use a conventional ferro in three-phase applications where it is impossible to guarantee a load balance within 15 percent because of peripheral device mix.
- c -- You can always use SCR tap switchers, or nonconventional three-phase ferros like datawave synthesizers, for three-phase power applications.

BEFORE YOU LEAVE THE SITE

Before you leave, tell the customer that the CE who installs the system will verify that any site modifications you have agreed on have been completed, before starting the installation. Be sure the customer understands that if he someday adds a component with tighter specs than the current system's, the site will have to meet those tighter specs. If your district has a policy that customer sites are inspected periodically, tell the customer approximately when you'll return.

TOOLS

SECTION:

5

This section includes *Support Update* articles describing the use of the site prep CE's tools; and a Recommended Tool List with ordering instructions. This section is not intended to duplicate the information in the tool manufacturers' manuals. Rather, emphasis is on articles describing how the tools are used to test for HP's specifications.

NEW SITE PREPARATION TOOLS

This article appeared in the *Support Update* of January 8, 1982.

PRSD has evaluated and selected two new site preparation tools: the Dranetz 626 Universal Disturbance Analyzer and the Holaday HI-3004 Field Strength Meter. See Figures 5-1 and 5-2.



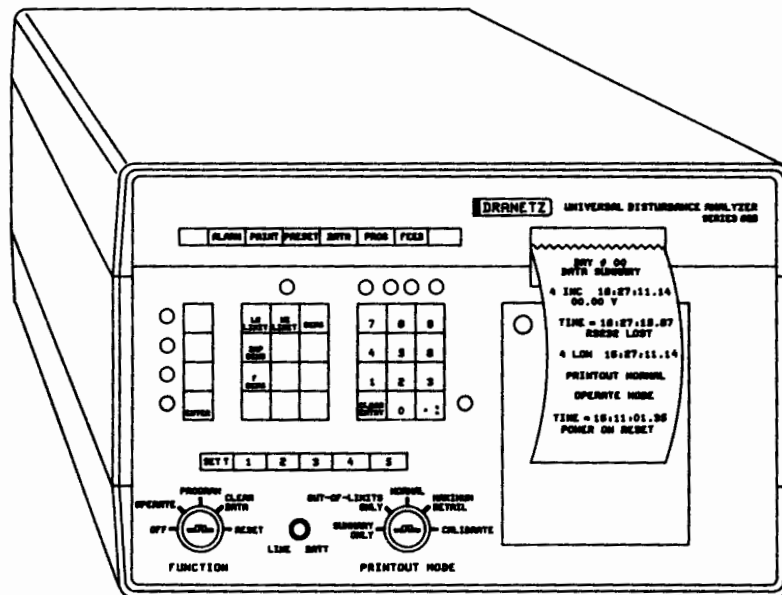


Figure 5-1. Dranetz 626 Universal Disturbance Analyzer

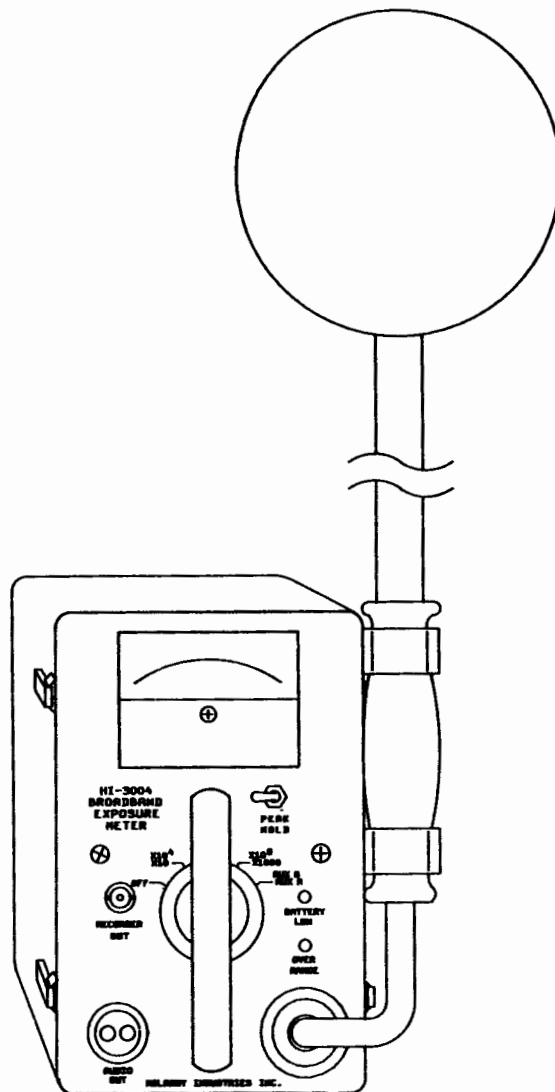


Figure 5-2. Holaday HI-3004 Field Strength Meter

Tools

Dranetz 626

The modular design of the 626 provides flexibility. In addition to its modularity (up to five modules), features include:

- a - keyboard entry of all threshold and clock settings.
- b - Built-in calibration and self-test.
- c - RS-232 port for remote access.
- d - Uninterruptable power system (UPS) provides 10-40 minutes of full operation in the event of power failure.
- e - Internal battery retains clock, thresholds and memory up to 6 months.
- f - Option 101 allows the operator to alter the detail with which disturbances are printed.

Modules of interest to HP include:

- a - The 6003-3 phase AC module--accepts inputs to 600 VAC and records sag, surge, undervoltage, overvoltage and impulse amplitude, duration, and time of occurrence. Also records impulse direction and frequency fluctuations.
- b - The 6006 AC neutral module--records the same disturbances as the 6003 except from 2-50 VAC. Useful for common-mode and neutral-ground voltage measurement.
- c - The 6002A DC voltage module--records DC voltage fluctuations and impulses. Voltage range on the 6002A is 0.5-80 volts and the 6002C is 25-600 volts.
- d - The 6008 temperature/humidity module--records temperature from 0-100 deg C +/-1 deg, and relative humidity 0-100%, +/-3%.

Holaday HI-3004

The 3004 is an improved version of the EFM-5 field strength meter (FSM) designed by the National Bureau of Standards for measuring radiated E-fields over a broad frequency range. The design of the unit overcomes many of the shortcomings of previous FSMs such as the EFS-1.

Features include:

- a - Readings from 0.3 to 30 volts/metre with one probe.
- b - Frequency range from 0.5 to 3GHz.

c - Isotropic probe using three dipole antennas. This arrangement is much less sensitive to E-Field polarity than a single antenna.

d - Peak-hold circuitry holds the maximum continuous wave or pulse-modulated signal recorded.

e - Rechargeable nicad batteries (up to 40 hours) with 'BATTERY LOW' indicator.

POWER LINE MONITORS COMPARED

The following comparisons of power line monitors appeared in *Support Update* from January 8 through February 5, 1982.

DRANETZ 626 VS. FRANKLIN 3600

This article summarizes the results of an evaluation of the Franklin 3600 and Dranetz 626 power monitors. Since both units are becoming quite popular, it was necessary to examine the merits of each and select a 'standard' HP unit. Four aspects were considered: mobility; ease of use; measurement accuracy; and flexibility.

Mobility

The 626 and the 3600 are portable and rugged enough for field use. For shipping, a case is available for the 626.

Ease of Use

Both units have self-tests which can be initiated on request. Both also have calibration circuits to determine the accuracy of the monitor inputs. If the self-tests and the calibration provide normal results, the operator can be confident that each unit works correctly.

The 626 and the 3600 are microprocessor-based with keyboard entry of thresholds, holds, time and date. The 626 does not allow invalid entries, for example a high voltage threshold lower than the low voltage threshold, or entering "30:76" for the time. This can happen with the 3600. In addition, the 626 retains time and threshold settings while the unit is off. The 3600 must be completely re-programmed whenever it is turned off.

Monitor cables can be plugged into either unit quite easily. Both offer the option of a snap-in or barrier strip connector.

Tools

Measurement Accuracy

Five tests were done to determine the units' accuracy: over/under voltage; sag/surge; impulses (normal and common mode); powerfail; and internal battery.

OVER/UNDER VOLTAGE. The over/under voltage test examined the accuracy of slowly-changing and steady state voltages. The 626 prints out accurate readings to 0.2 volt resolution. The 3600 prints out to a 1-volt resolution and has an LED panel displaying the current voltage.

SAG/SURGE. A sag or surge, by definition, is an AC voltage anomaly lasting for a short period of time. The 626 makes this distinction at 2.56 seconds. Longer fluctuations are considered over or under voltage. In either case, the time is printed to the nearest 10 ms, so the duration can be determined.

The 3600 makes no distinction between sag/surge and over/under voltages. If a disturbance exceeds the threshold and lasts for 1 second or longer, the duration is printed to 1.0 second accuracy. If the condition lasts less than one second the duration is printed to 10 ms accuracy.

IMPULSES. The 626 measures impulses up to 4000 volts and 2000 usec whereas the 3600 measures impulses to only 1500 volts and 1000 usec. The 3600 also had problems reporting accurate polarities and phases on common mode impulses.

POWERFAIL. The powerfail tests were to determine the response to line dropouts varying from 1 ms to 10 seconds. Both units reported the conditions, but the 626 provided more information with respect to duration due to its time printout characteristics.

INTERNAL BATTERY/UPS. This test was to determine how long the units will operate on battery after being fully charged. Both units automatically shut off at low battery power while still retaining memory. The 3600 continued functioning longer on the UPS.

DRANETZ 606 VS. 626

The Dranetz 606 Power Line Disturbance Analyzer was HP's "standard" power monitor for several years. The 626 with a 6003 three-phase AC module monitors essentially the same disturbance. However, in some cases the measurement technique is different. The major differences involve slowly-varying voltages, sags, and surges.

SLOWLY-VARYING VOLTAGES. For the 606, this is called SLOW AVG for slow average. A 10 second (600 Cycle) moving window is used to determine the average voltage. Every cycle a new 600 cycle average is calculated. If the current average differs from the last printed slow average by +/-the SLOW AVG threshold, a printout results. The

10 second average is also used by the 606 as a reference level for sags and surges. See Figure 5-3.

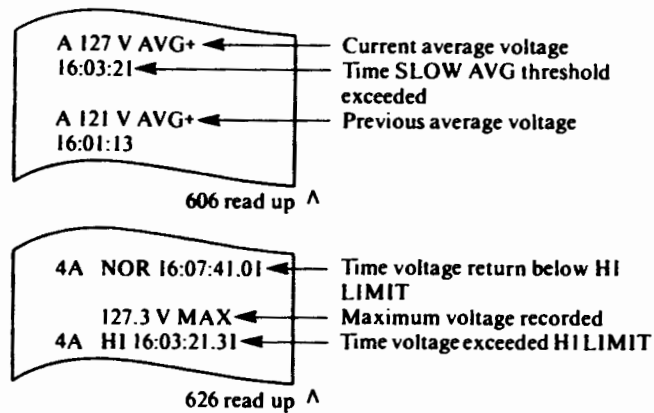


Figure 5-3. Slowly-Varying Voltage

The 626 does not make a slow average measurement. If the voltage level exceeds the HI or LO LIMIT longer than 2.55 seconds, a printout results.

SAGS AND SURGES. The 606 measures the RMS voltage of each cycle and compares it to the current reference voltage from the 10 second window. If the current cycle voltage differs from the reference by the Sag/Surge threshold setting, a counter begins counting the number of cycles the condition exists. When the voltage returns to within the threshold, a sag or surge disturbance is printed. See Figure 5-4.

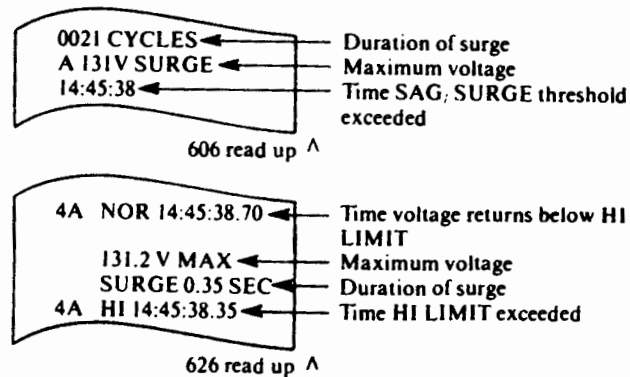


Figure 5-4. Surge Printout Examples

The 626 determines the RMS voltage of each cycle and compares it to the HI and LOW LIMIT, not a moving window. When a threshold is exceeded a timer starts counting. If the condition lasts for less than 2.56 seconds the disturbance is recorded as a sag or surge.

IMPULSES. In the 606 an impulse is the peak transient measured over a 2 cycle, 33 msec period with a duration between 0.5 and 800 usec. An impulse is detected by first filtering out the 50 or 60 Hz AC line and comparing any transients to the IMPULSE threshold. If the impulse duration is less the 0.5 usec it may not be recorded due to the notch filter rolloff. Impulses greater than 800 usec may also be attenuated due to rolloff or may indicate an erroneous sag or surge condition. The maximum impulse recorded is 1024 volts. See Figure 5-5.

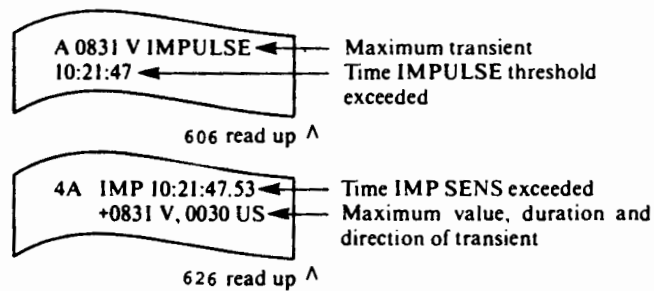


Figure 5-5. Impulse Printouts

In the 626 an impulse is the peak transient measured over a 10 ms period with duration between 1 and 2000 usec. The maximum impulse recorded is 4000 volts. The impulse measurement in the 626 is clearly more accurate and detailed than the 606.

In summary, the 606 uses a 10 second moving window as a reference for slow average and sag/surge measurements while the 626 compares the current voltage to absolute threshold levels. The impulse measurements are essentially the same, but the 626 is more accurate and informative.

DRANETZ 626 REMOTE ACCESS

A standard feature of the Dranetz 626 is an RS-232 interface which allows for remote access of all information recorded by the 626. This article describes setting up and using this capability.

EQUIPMENT LIST

- 1-Dranetz 626
- 2-HP 35016A Modem or equivalent
- 1-HP 30062-60020 Cable
- 2-HP 0960-0646 Data Station Adaptor
- 2-HP 1251-5870 TEE Connector
- 1-Terminal with serial I/O cable

Tools

Equipment Set-Up at Customer Site

For the following steps, see Figures 5-6 and 5-7.

1. Place the 626 on site and program it for the time and thresholds wanted. The 626 cannot be programmed remotely. Connect the RS232 port of the 626 to the HP 35016A Modem using a 30062-60020 cable, and be sure that the communication module of the 626 is configured for 1200 baud (the baud rate of the modem). See the 626 manual for information and instructions.
2. Connect the modular jack of the modem to the Data Station Adaptor, Part No. 0960-0646.
3. Connect the modular jack of the adaptor to one input of the TEE Connector, Part No. 1251-5870, and connect the telephone jack to the other input of the TEE Connector.
4. Connect the output of the TEE Connector to the phone line.
5. Configure the modem Exclusion Key to MA (Manual) for voice communication (see Figure 5-6). This allows normal operation of the customer's phone until remote accessing is wanted.

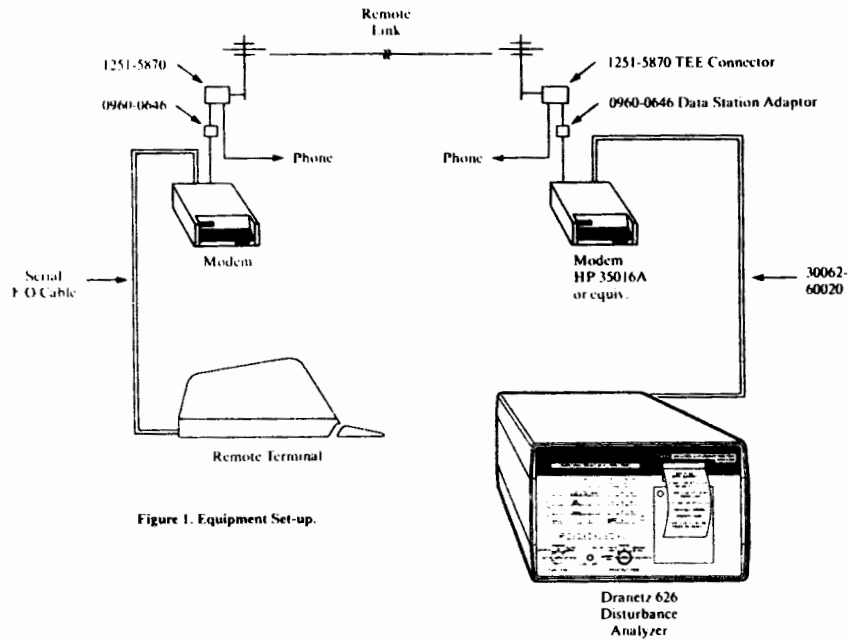


Figure 1. Equipment Set-up.

Figure 5-6. Remote Equipment Set-Up

Tools

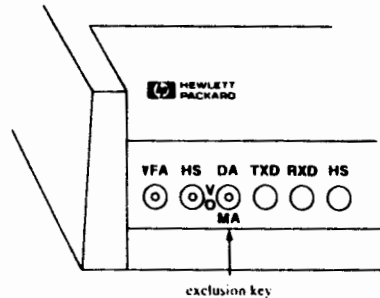


Figure 5-7. Exclusion Key in Manual Mode

Equipment Set-Up, HP Site

1. Connect a terminal to the modem's RS232 port using the appropriate serial I/O cable listed below. See Figure 5-6.

264X Terminal	02640-60131
262X Terminal	13222-60001
HP 85 Service System	35050-60001

Select 1200 baud on the terminal. Refer to the respective operator's manual.

2. Steps 2-5 are identical to the set-up at the customer's site.

Establishing the Remote Link

1. Telephone the customer. Instruct him to depress FA (Forced Answer) on the modem (see Figure 5-7).

2. When you hear a high-pitched tone, switch the exclusion key on your modem from MA (manual) to DA (data) and hang up. If the link is established correctly a message indicating the time and reading "RS232 RESTORED" is printed and transmitted.

3. Several options now exist for remote operation. They are described in the next Paragraph.

4. When finished, switch the exclusion key back to MA. This breaks the remote link and restores voice communication to each location.

Remote Access Options

Once the remote link is established, all recordings are transmitted to the terminal. If the printer is on, then all recordings are also printed at the customer's site. If the remote link is broken while the printer is off, the printer will automatically turn on so that no information is lost. Shown below is a list of available commands and their functions. These commands override front panel switches which select the same functions.

TYPE IN COMMAND	RESULT
P	Transmit program summaries of all modules
C	Calibrate
D	Transmit data summaries of all modules
A	Auto-clear mode - selects automatic
M (Toggle)	data summary reset at 12 midnight or Manual clear mode - selects manual data summary reset by remote access
K	Prints out current data summary and then resets data summary when in the manual clear mode only.

An unusual feature is available with the remote data reset commands (M and K) described above. Since the 626 will typically be accessed for brief and sporadic periods of time, remote data reset provides the ability to obtain a current data summary of all disturbances since the last time the unit was reset. (See the 626 operator's manual for the maximum number of disturbances that can be recorded before data overflow occurs.) This way, data can be recorded and accessed remotely for any desired length of time.

In the case where a modem is available at the customer's site but dedicated to another piece of equipment (such as remote diagnostics), an RS232T switch can be purchased from outside vendors which selects one of two inputs, the equipment or the 626. When remote access is desired the customer is requested to throw a switch instead of moving cables. The remote link is then established as described above and the information transmitted. When finished the link is disconnected and the customer asked to switch back to the dedicated equipment.

EMI MEASUREMENTS

This description of EMI measurements appeared in the January 8 and January 22, 1982 *Support Update*.

DEFINING EMI AND MEASUREMENT TECHNIQUES

Like many environmental problems, the effects of Electromagnetic Interference (EMI) on computer equipment generally tend to show up as intermittent problems. Disc drive faults, timing errors or an unsteady CRT display could all be attributed to EMI. Thus, it can be a difficult problem to isolate and it is, therefore, important to assure that customer sites remain within HP's recommended specs, which start as low as one-half volt/metre, from 14 kHz to 1 GHz.

EMI and Its Sources

The American Heritage Dictionary defines an electromagnetic field as "The field of force associated with electric charge in motion..." This field of force radiates out from moving charges at the speed of light and, depending on how fast the charges are moving back and forth, sets up a periodic change in strength of the field.

As a rough example, consider a float resting on the surface of a trough of water. If waves are formed at one end of the trough, they will propagate out towards the float. When the waves reach it, the float will be subject to a vertical force at right angle to the direction of propagation of the waves and thus will start bobbing up and down.

If the float is replaced by an electric charge and the speed of propagation by the speed of light, then the waves represent an aspect of the field strength. First, the force on the float increases as the wave pushes it up, then diminishes as the float reaches the crest of the wave. The force then increases in the opposite direction, the float drops, and then diminishes and so on. The force on the float (charge) transferred to the field is in a direction perpendicular to the propagation of the field.

The strength of the field has both amplitude and direction. The amplitude is made up of two parts whose direction is separated 90 degrees with respect to each other. The direction is also referred to as the polarity of the field. The periodic change in strength can be measured in terms of frequency and wave length (where the wave length is the length of one period of the associated wave).

The frequency range extends from zero to over 10 to the 23rd cycles per second and includes radiation associated with power, heat, radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays, and cosmic rays in that order (see Figure 5-8). This

radiation is generated from a variety of sources, both man-made and natural.

Tools

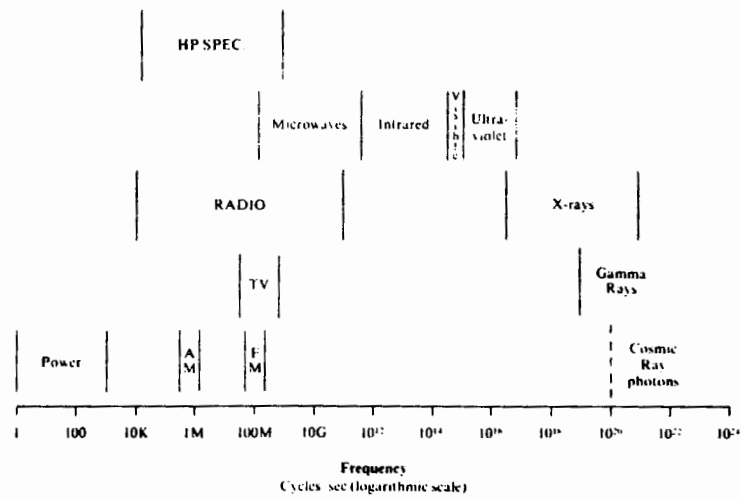


Figure 5-8. The Electromagnetic Spectrum



Frequency Range of Equipment Susceptibility

The frequency range cited in HP EMI specifications is 14 kHz to 1 GHz. This range corresponds to the major frequencies used by communication equipment which is often the source of EMI problems. Beside radio stations and TV, mobile communication equipment like transceivers ("walkie-talkies") can cause interference, and be very hard to trace because of intermittent use.

Defining Volts per Metre

In order to develop a 'feel' for EMI problems it is valuable to understand more about the nature of EMI and the terms used to express it. HP's recommended specifications start as low as one-half volt per metre. Let's take a look at what electromagnetic radiation consists of. As stated before and implied by its name, electromagnetic radiation is made up of two parts: the electric and the magnetic fields.

The Electric Field

The electric field is a characteristic of the charge on a particle and is defined as "the force per unit charge." Expressed as an equation:

$$E = F/Q$$

Where:

E is Electric field strength in newtons per coulomb

F is Force exerted on particle in newtons

Q is Charge of particle in coulombs

The equation shows that E-field strength is measured in newtons per coulomb, but if numerator and denominator are multiplied by the dimension of length in meters, one derives the equation $E = \text{Volts per meter}$.

Volts per metre is the standard unit for expressing E-field strength. A situation where it is easy to see the application of these units is a parallel plate capacitor. Inside the two plates an E-field exists that is equal to the potential difference in volts of the two plates divided by the distance between them, yielding volts per metre.

The Magnetic Field

The magnetic field is a characteristic of the movement of charge. On the atomic level this is simply the spin and movement of an electron around an atom. On a large level this movement is detected as current, and yields a magnetic field with the dimensions of

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amperes per metre. As can be seen dimensionally and from Ohm's law, $V=IZ$ or $Z=V/I$, one should be able to relate the electric field to the magnetic field with a quantity having the dimensions of impedance.

This is in fact the case, and for areas distant from the radiation source, termed the far field, this quantity is the intrinsic impedance of free space and is equal to 376.7 ohms. Thus, in the far field the magnitude of the electric field is going to be 377 times the magnitude of the magnetic field. Since one can control or is at least often aware of the radiation sources in the near field, then the important quantity to measure is the electric field because it is the dominate effect in the far field.

Measurement Devices

Two instruments that measure electric field strength are: (a) the broadband field strength meter (FSM) and (b) the spectrum analyzer/calibrated antenna arrangement. With either method, one should understand what parameters of the electromagnetic field are being measured. Generally, these electric field parameters are: instantaneous strength; peak strength; polarity; and frequency.

The detection of these parameters is done with an antenna. In the case of the broadband FSM, the antenna is often attached to the unit or provided as a hand-held probe.

Broadband Field Strength Meter

The instantaneous E-field strength is shown on a meter or display in volts per metre. This value usually indicates the field strength of a continuous signal.

The peak value of the field strength is the value that typically causes intermittent problems and is also the most difficult value to measure.

The peak E-field strength is an important FSM parameter to consider because:

a - Depending on the type of modulation (for instance Pulse Amplitude Modulation used on communication equipment) the peaks may not appear on the meter movement or display. Therefore, peak hold circuitry is necessary to capture such fields.

b - Transient peaks may occur that happen too fast for the meter movement and so these also need to be captured.

c - Unattended monitoring is possible by reading the peak value after an extended time.

The polarity of the E-field strength can be measured. This involves rotating the antenna through 360 degrees horizontally and vertically in order to pick up the strongest instantaneous reading. Obviously, this does not work very well for the peak value, since one does not normally know what polarity to expect, and cannot rotate the antenna continuously. However, by orienting 3 antennas 90 degrees apart in each of 3 different directions and taking a vector sum of the signal strength on each of them, one obtains an antenna arrangement that is not sensitive to E-field polarity. This is referred to as an isotropic antenna.

The frequency of the E-field is not displayed by a broadband FSM since it is an instrument unaffected by frequency over a wide range. In fact, an important specification of the FSM is how consistent or 'flat' its response is to constant magnitude fields whose frequencies vary within its specified range and also, how large that range is. The source of the previously-mentioned parameters may not be so easily deduced, however, due to the presence of several fields at the same location, these fields can normally be distinguished from each other by a difference in frequency.

If the FSM indicates a field strength greater than HP specifications and the source is not obvious (like a radio station next door) then a spectrum analyzer and calibrated antenna combination can be used to accurately determine both the amplitude and the frequency of the radiation present at the site.

Spectrum Analyzer

Compared to a broadband FSM, there are significant differences in determining field strength in volts per metre with a spectrum analyzer. These differences are the units read from the spectrum analyzer (dBm) and how the calibrated antenna is factored into this reading (antenna factor). The antenna factor is usually supplied by the manufacturer of the calibrated antenna in the form of a chart or graph that lists the antenna factor as a function of frequency.

This takes into account the effective length of the antenna as well as mismatch and transmission line losses. If supplied in linear form (per metre), this quantity is multiplied by the voltage read on the spectrum analyzer to come up with a field strength in volts per meter. Usually however, this term is supplied in logarithmic form (dB per meter) and is therefore added to the reading (in dB Volts) obtained from the spectrum analyzer to yield a field strength in dB Volts per meter. In equation form:

$$E = K * V$$

$$\text{or}$$

$$EdB = KdB + dBV$$

Where:

E is Field Strength in Volts per meter
 EdB is Field Strength in dB Volts per meter
 K is Antenna factor in Meters to the -1 (per meter)

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KdB is Antenna factor in dB Volts per meter
V is Analyzer voltage in Volts
dBV is Analyzer voltage in dB Volts

How do you obtain Volts or dB Volts from the spectrum analyzer which reads in dBm? The unit dBm is short for dB milliwatts and is thus a power measurement. So, the voltage can be calculated from the power formula:

$$P = V^2/Z$$

Where:

P is analyzer power in watts
V is analyzer voltage in volts
Z is analyzer impedance in ohms (usually 50 or 75)

Or, in logarithmic form:

$$\text{dBm} = 20 \log V - 10 \log Z + 30.$$

Solving for V:

$$V = \sqrt{(Z \cdot 10^{\text{dBm}/10}) / 1000}$$

or

$$\text{dBV} = \text{dBm} + 10 \log Z - 30$$

Going back to the formula for field strength:

$$\text{EdB} = \text{Kdb} + 10 \log Z - 30$$

For more information on calculation of field strength using a spectrum analyzer, refer to Spectrum Analyzer Series Application Note 150-10.

Using Broadband Field Strength Meters

The remainder of this article concentrates on two models of broadband field strength meters (FSM), and broadband field strength measurements in general. The two FSMs to be compared are the Holaday Industries HI-3004, and the Instruments For Industry (IFI) EFS-1. We will use the parameters previously described as the basis for our comparison.

AVERAGE STRENGTH. The average strength of the electric field is displayed on meter movements on both instruments and thus offers no advantage for either instrument.

POLARITY. The polarity of the EM wave does not effect the response of the HI-30 because it has an isotropic antenna. With an isotropic antenna the operator can scan an area without regard to probe orientation. At each test point the EFS-1, however, has to be rotated in each of two planes (the EFS-1 is approximately symmetric about the plane whose axis includes the antenna) in order to determine the strongest field strength.

FREQUENCY. Consider the frequency range of the two instruments and how their response corresponds with the electric fields present at a computer site. The frequency range of the EFS-1 is 10KHz to 200MHz. On the low end where there is less commercial use, say below 500KHz, the frequency response of the EFS-1 can be a disadvantage.

Examples are HP 264X terminals which operate with a flyback transformer at 150KHz because the field measured may be dominated by the terminals and not necessarily an unwanted outside signal. Above 200MHz the EFS-1 frequency response starts to drop off and at approximately 350 to 400MHz it starts resonating. There is still a lot of commercial use in this frequency range, including TV, radio and microwave broadcasting. The frequency range of the HI-3004 is 500KHz to 3GHz; this matches the frequencies likely to be present at a computer site.

OTHER CONSIDERATIONS. There are three other areas in which the HI-3004 has an advantage over the EFS-1 that directly effect its ease of use. The first is an automatic zeroing feature which constantly checks the meter zero on the HI-3004. The EFS-1 meter zero needs to be checked virtually every time the instrument is used.

The other advantages involve the antenna and its connection to the instrument. The HI-3004 has an antenna mounted on a probe handle that can be held away from the body, thus reducing perturbations to the field caused by the operator. The antenna on the EFS-1 screws directly into the case. To move the antenna away from the operator's body, the case and the meter with it must be moved away. This makes it difficult to read as well as introducing the possibility of the case interfering with the field being measured.

A light modulator unit with a fiber optic link may be purchased to further remove the operator from the antenna, but this approximately triples the price of the instrument. Finally, the EFS-1 needs at least two antennas to cover the same amplitude range as the single probe of the HI-3004, making it less convenient to use.

SUGGESTIONS. Due to the these factors and inputs from several of the manufacturing divisions, PRSD suggests using the HI-3004 instrument for broadband field strength measurements. PRSD further suggests that the EFS-1 no longer be purchased.

Effective Use of the HI-3004

An isotropic FSM (like the HI-3004) responds to multiple frequencies, directions and polarities of the electromagnetic field. The magnitudes of all the frequencies contribute to the total field strength in each of the three directions of the mutually orthogonal antennas. The root-sum-square (or Hermitian) value E is equal to the square root of the sum of the squares of the three frequencies.

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Knowledge of the isotropic antenna response is essential to understanding the difference between broadband measurements and field strength measurements made with a frequency-selective device like a spectrum analyzer. Since a spectrum analyzer indicates a single frequency at a time, the field strength may be less than that measured with the HI-3004.

With a spectrum analyzer, you must also search for the strongest value of field strength by rotating the antenna. In most cases HP equipment is affected by signals of a specific frequency. However, the 3004 is very useful in eliminating EMI as a possible cause of problems, as well as capturing random signals. If the 3004 indicates the field strength is greater than HP specifications, it may be responding to multiple signals at different frequencies, no one of which, when measured alone, exceeds the spec.

At that point, a consultant with more specialized equipment should be brought in to determine if multiple frequencies are contributing to the excessive reading or if, in fact, there is an excessive dominant frequency. Intermittent bursts of EMI may not be detected in a single site survey and there are other factors, described next, that can affect field strength.

LONG-TERM EMI MEASUREMENTS

This article appeared in the *Support Update* of August 20, 1982.

Holaday Industries is shipping the HI-3110 Recorder Output Amplifier which is part of HP's purchase agreement for HI-3004 Field Strength Meter. This amplifier is used to interface the HI-3004 with either the Dranetz 626 with a DC module, or one of the DC channels on the Dranetz 616. The combination of the HI-3004, amplifier, and a Dranetz allows for continuous, long-term monitoring of a site with hardcopy printouts of any disturbances.

The HI-3110 Recorder

The characteristics of an HI-3110 Recorder are listed next. See Figure 5-9.

- a - Input connects directly to Recorder Out on the 3004.
- b - Output of amp is directly compatible with 626 DC module and 616 DC channel.
- c - "ON" LED blinks for normal operation.
- d - "BAT LOW" LED is on when batteries are low.

- e - Mode switch selects "VREF" (internal reference voltage) or "REC.OUT" (normal operating position).
- f - GAIN adjusts from a gain of 1 to 10V.
- g - OFFSET adjusts zero level from 0 to 5V.
- h - Unit operates off internal rechargeable batteries, or off the charger if it is plugged in.

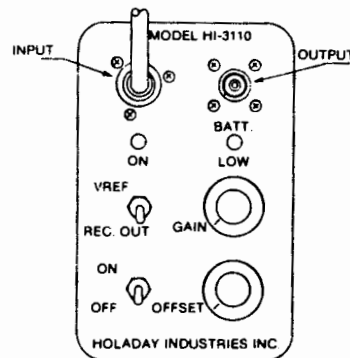


Figure 5-9. HI-3110 Recorder Output Amplifier

Using the HI-3110 With the Dranetz 626

To use the HI-3110 with the DC module on the 626, follow these steps:

1. Program the 626:

Range F.S.	20.0V
V High Limit	7.3V
(corresponds to 0.5V/M on the 0-1 V/M scale)	
V Low Limit	0.5V
Voltage Sens	0.5V

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Impulse Sens	2.0V
Printout Mode:	Normal

2. Make connection from the HI-3110 to the 626.
3. Select "REC.OUT" on the HI-3110 and, with the HI-3004 off, adjust for a 5V offset.
4. Select "VREF" on the HI-3110 and adjust the gain for 15V out (output range: 5-15V).
5. Select "REC.OUT" and turn on the HI-3004 to the desired scale.
6. Plug in the battery chargers if needed for long term monitoring.

A comparison chart appears at the end of this article, showing the relationship between the output volts as recorded on the 626 or 616, and the volts/metre reading on the Holaday Recorder.

Using the HI-3110 With the Dranetz 616

To use the HI-3110 with a DC channel on the 616, follow these steps:

1. Program the 616:

Slow Avg.	3.3V
Sag/Surge	0.3V
Impulse	2.0V
2. Connect Channel A (AC) to any standard AC outlet. (All DC measurement intervals are based on AC cycles as determined by Channel A.)
3. Power on the 616 but leave the HI-3004 off.
4. Select "REC.OUT" and adjust the offset for 5V.
5. Select "VREF" and adjust the gain for 10V output (output range is 5-10V).
6. Select "REC.OUT" and turn on the HI-3004 to desired scale.
7. The battery chargers should be used if needed for long-term monitoring.

Be aware that the 616 loads the HI-3110 down such that the full gain of 10 (5-15V output range) may not be achievable.

Comparison of Dranetz and Holaday Readings

DRANETZ 626

V out: output volts recorded on 626

V/M: volts per metre reading on HI-3004

V out	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
0-1	0.21	0.31	0.41	0.46	0.52	0.57	0.61	0.65	0.69	0.73
0-3	0.80	1.03	1.25	1.47	1.64	1.79	1.94	2.06	2.18	2.29
V/M										
0-10	2.12	3.12	4.07	4.65	5.19	5.65	6.11	6.51	6.92	7.27
0-30	8.10	10.31	12.52	14.73	16.38	17.94	19.36	20.55	21.80	22.94

DRANETZ 626 Continued

V out	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00
0.1	0.76	0.80	0.82	0.85	0.88	0.90	0.93	0.95	0.98	1.00
0.3	2.41	2.51	2.60	2.69	2.78	2.86	2.93	3.00	3.08	3.16
V/M										
0.10	7.61	7.95	8.23	8.51	8.78	9.05	9.28	9.52	9.76	10.00
0.30	24.07	25.05	26.04	26.94	27.84	28.57	29.26	29.96	30.80	31.64

DRANETZ 616

V out: output voltage from DC channel on 616

V/M: reading from the HI-3004

V out	5.50	5.75	6.00	6.25	6.50	6.75	7.00	7.25	7.50	7.75
0-1	0.32	0.41	0.46	0.52	0.56	0.61	0.65	0.69	0.72	0.76
0-3	1.06	1.26	1.47	1.64	1.80	1.94	2.07	2.19	2.31	2.41
V/M										
0-10	3.19	4.07	4.64	5.17	5.64	6.10	6.49	6.89	7.24	7.57
0-30	10.57	12.62	14.67	16.40	18.00	19.35	20.68	21.90	23.08	24.13

DRANETZ 616 Continued

V out	8.00	8.25	8.50	8.75	9.00	9.25	9.50	9.75	10.00
0-1	0.79	0.82	0.85	0.88	0.90	0.93	0.95	0.98	1.00
0-3	2.52	2.61	2.70	2.79	2.86	2.93	2.99	3.08	3.17
V/M									
0-1	7.91	8.20	8.48	8.76	9.04	9.28	9.52	9.76	10.00
0-3	25.17	26.11	26.98	27.86	28.58	29.26	29.95	30.82	31.71

Tools

MORE ABOUT THE DRANETZ 606 AND 626

This article appeared in the *Support Update* of August 19, 1983.

When the Dranetz 606 and 626 Universal Disturbance Analyzers ('power monitors') were introduced to the field, the goal was to obtain accurate information before suggesting that the customer consider a power line treatment device. To a large extent this has been achieved. However, a few power disturbances may not be monitored accurately enough to get the information needed. In particular, these disturbances are sags/surges and notches. This article will look at how the 606 and 626 monitor each anomaly and provide methods to obtain accurate information.

Sags and Surges

There are two basic types of sags or surges: those generated by dynamic load changes within a building, and those generated on the power grid itself and transmitted into a building. Figures 5-10 and 5-11 illustrate typical waveforms for each type of sag.



Figure 5-10. Typical Load Sag Waveform



Figure 5-11. Typical Grid Sag Waveform

Notice that the load sag drops to its low point at cycle 1, then recovers exponentially to nominal. This nominal may not be the same as before the sag because the added load could result in a lower nominal voltage.

The grid sag also hits the low point at cycle 1, but stays there. There is usually no exponential recovery, but rather an abrupt end resulting in restoration of the original nominal.

Clearly the grid sag is different from the load sag, with different affects on the computer. Most HP computer equipment can withstand a one cycle voltage anomaly below its powerfail threshold (for 120 V devices this is typically 108 V). In Figure 5-10, the load sag is below 108 V for one cycle, then recovers to 110 V at cycle 2. This sag would not cause a powerfail. However, the grid sag in Figure 5-11 stays below 108 V for four cycles and would cause a powerfail. Let's look at how the 606 and the 626 would measure these sags.

The 606

Many field engineers set the sag/surge threshold on the 606 for 3 V when monitoring a 120 V line. Let's use this for an example. Let's say the nominal has been 120V for some time. See Figure 5-12.

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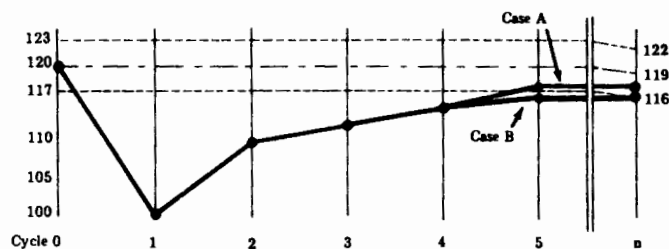


Figure 5-12. Load Sag With 606 Thresholds

In the first case, the voltage recovers to 118V in Cycle 5. At that point the sag is over and the 606 prints:

```
0004 CYCLES
A 100V SAG
time          read up
```

With normal accuracy error, the disturbance could be as much as 5 cycles at 98V.

In the second case, the voltage recovers to 116V and stays there. The sag will continue to be counted until the internal voltage reference drops to 119 V. No SLO AVG printout will be made unless the last printed SLO AVG was 122 V (for a 3 V threshold) or 124 V (for a 5 V threshold). At the time the reference voltage changes to 119 V the sag is over with n being perhaps 30 to 40 cycles. The printout in this case could be:

```
0030 CYCLES
A 100V SAG
time          read up
```

If the same thresholds are used for the grid sag, the result would look like Figure 5-13.

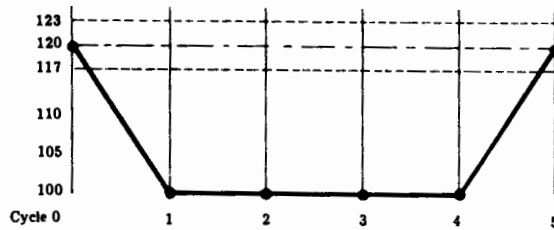


Figure 5-13. Grid Sag With 606 Thresholds

The printout in this case would be very similar to that of the load sag:

```
0004 CYCLES
A 100V SAG
time          read up
```

In each case there appears to be a need for voltage regulation. However, there is no way to tell, especially since the worst case did not cause any problems at all. The most we know from this is that something happened.

606 Interpretation

Obviously, knowing only that something happened is not enough. How do we get the information needed to determine if voltage regulation is needed? Here are some suggestions:

- Disregard sags or surges of 3 cycles or less unless you have additional information.
- If the nominal is stable, set the threshold so a sag can only occur near the equipment's powerfail level. Be careful not to exceed surge limitations. In the examples above, if a 10 V threshold had been used, the load sag would have been 2 cycles (ignore) and the grid sag would have been 4 cycles (problem).
- Keep the SLO AVG threshold set to minimum. The SLO AVG is also the reference voltage and is constantly updated. A SLO AVG printout occurs only when the reference voltage differs by more than the threshold from the last printed SLO AVG.

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The 626

Next, let's examine how a 626 would measure the previous events. Recall that the 626 uses a minimum and maximum voltage threshold which is operator-programmable. These thresholds should be set for the system voltage specs, typically 125V and 108V. The printouts from the load sag and grid sag are (load sag left, grid sag right):

4A NOR time	4A NOR time
100.0 V MIN	100.0 V MIN
SAG 0.02 SEC	SAG 0.08 SEC
4A LO time read up	4A LO time read up

Notice that the accuracy error could result in times of 10 to 40ms for the load sag, and 70 to 100 ms for the grid sag.

These printouts give much more accurate information than the 606, but there is still uncertainty with respect to sags less than 50 ms.

626 Interpretation

The 626 provides good information on voltage disturbances greater than 3 cycles. On events less than this, the accuracy error comes into play so that distinguishing between a one cycle or three cycle anomaly is difficult. In these circumstances you will have to trust your own judgement, based on your experience.

Notches

Notches are line dropouts lasting usually less than one cycle. They can be generated by many different items such as equipment switches, power factor correction capacitors, and unpredictable occurrences on the power lines. The 626 and 606 monitor notches in a similar manner. Their basis for measurement is a cycle-by-cycle average of the voltage. So, a notch could be represented in several different ways, all of which can be confusing and misleading.

For a long notch, say half a cycle to a full cycle, both devices will recognize a low cycle average voltage and label it as a sag. Due to a timing error in each device, the sag could be printed as being two to three cycles long - clearly not what is really happening (recall the preceding description of sags). Since the falling and rising edges of a notch are rather steep, the devices often print out that an impulse also occurred. An impulse may, or may not, be associated with a notch. Again, the results printed out may be misleading.

This problem with false impulse measurements is intensified if the notch is of a short duration -- an eighth of a cycle or less. In this case, no voltage disturbance is detected, but the edges often cause impulse printouts.

Two characteristics of these false impulses are worth noting. First, the amplitudes will be within the peak voltage envelope of the voltage. For example, a 120 volt source has a peak envelope of +/- 170 volts (actual peak volts may be as high as 190 volts). The false impulse amplitudes will be less than this value for all cases. Impulse amplitudes far exceeding this envelope are actual impulses.

Second, since the false impulses are generated by notches, and notches are not affected by linear devices (isolation transformers and tap switchers), they will appear on the input and on the output of an isolating device. This can be very confusing and lead to conclusions that the device does not work or does not work well enough. Once again, the information given is not what is occurring.

In summary, both the Dranetz 606 and 626 may provide false or misleading information about notches. A disturbance which will not affect the computer can be misunderstood as indicating a need for isolation and/or regulation. The question must be asked as to how we can detect a notch and interpret it properly.

Interpreting Notches

Short term sags and false impulses may cause notch printouts. Interpreting sags was described previously. These short term sags, without any other information, quite often do not indicate a need for regulation.

Impulses can be distinguished from notches. As previously stated, a notch will not be affected by a linear transformer device such as an isolation transformer or tap switcher. If the device is a good isolator, however, an impulse will be attenuated. So, by placing a small isolation transformer in the power lines and monitoring the input and the output you can tell the difference. An impulse will be seen on the input only, while a notch will be seen on both the input and output.

HP 4329A HIGH RESISTANCE METER

The following information is summarized from the HP 4329A High Resistance Meter spec sheet.

The HP 4329A is a solid-state insulation resistance meter designed for direct readings of the very high resistance values typically found in synthetic resins, porcelain, insulating oils and similar materials. It is also useful for measurements in electrical components like capacitors, transformers, switches and cables. Seven fully-regulated DC test voltages (between 10 and 1000 V) are provided as test sources.

Selected scales are identified by illuminated indicators on the meter face. Selected resistance or current multiplying factors are

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also illuminated for rapid measurement. Three resistance scales and one current scale are provided. The HP 4329A is instantly convertible from ungrounded-to-grounded-sample operation via a relocation of the front panel ground strap from "guard" to "+" position. The instrument cabinet itself is always at ground potential. Test voltage shorts or sample breakdown currents will not damage instrument circuitry.

The HP 4329A also has a current measurement capability. Current as small as 0.05 pA can be measured. The standard instrument package includes HP 1617A Low Noise Test Leads; these are used in most types of measurement.

Use of the HP 16008A Resistivity cell alters the HP 4329A's measurement accuracy. However, the measurement error is consistent and repeatable. This is true as long as the measurement set-up is not changed.

HP 4329A Specs

RESISTANCE MEASUREMENTS

Range: 500k ohms to 2×10^{16} ohms

Accuracy: total accuracy is determined by test voltage and range used. At low resistance end of each scale, accuracy is $\pm 3\%$, near center scale $\pm 5\%$, and near the specified upper limit on the meter scale, accuracy is $\pm 10\%$. Accuracy is not specified above these limits. On all voltage ranges, if multiplier is set to Rmax., an additional $\pm 3\%$ is included.

CURRENT MEASUREMENTS

Range: 5×10^{-14} to 2×10^{-5} A in 8 ranges.

Meter scale: 0 to 20 in 40 linear divisions.

Input resistance: 10^4 to 10^{11} ohms $\pm 1\%$, depending on range.

Accuracy: $\pm 5\%$ of full scale deflection (there can be an additional $\pm 3\%$ error at the top decade).

GENERAL

Recorder output: 0 to 100 mV DC, proportional to meter deflection: 1k ohms output resistance.

Power: 115/230V $\pm 10\%$, 50-60 Hz, approximately 3 VA.

Size: 166 mm H, 198 mm W, 224 mm D

Weight: 3.5 kg

Dec 86; Internal Only
5-32

Accessory Furnished: HP 16117A Low Noise Test Leads.

Accessory Available: Model 16008A Resistivity Cell.

The 16008A Resistivity Cell

The HP 16008A measures the volume and surface resistivity of various material (like carpeting). Conversion from volume to surface resistivity measurement requires operation of one switch only; no lead interchange or disconnection is necessary. Designed for use with the HP 4329A Resistance Meter (other voltage supplies and picoammeters may be used), the complete system allows direct measurement of volume resistivity up to approximately 4×10^{18} ohms/cm (on samples 0.1 cm thick) - and surface resistivity up to approximately 4×10^{17} ohms. Test voltages up to 1000V can be used. See Figure 5-14.

16008A Specs

Inner electrode: 50mm diameter.

Guard electrode: 70mm diameter.

Auxiliary electrode: 100mm x 120mm.

Maximum sample size: 125mm x 125mm x 7mm.

Maximum test voltage: 1000 VDC.

Size: 49mm high; 198mm deep.

Weight: 1.8 kg.

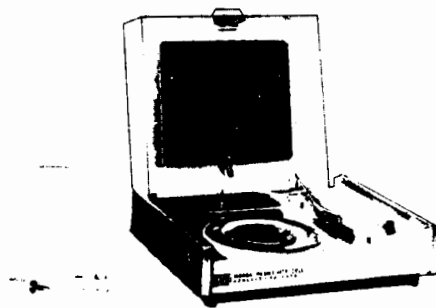


Figure S-14. HP 4329A (Top); 16008A Cell (Bottom)

ACL 300 ELECTROSTATIC LOCATOR

The following is taken from the ACL 300 spec sheet.

The ACL 300 provides on-the-spot static measurements. It answers three basic questions: (a) Is static present and on what surfaces, materials or people? (b) If so, how much is present? (c) If present, what is the polarity of the charge? The instrument is used in such sensitive environments as electronic component production and assembly areas, clean rooms, computer, medical and R & D laboratories, surgical rooms, medical device manufacturers, printing presses, and packaging and production lines.

No auxiliary attenuators or heads are required. To minimize error from extraneous static fields, the unit utilizes a recessed nickel-plated sensing electrode which operates on a high/ low circuit. The low range measures 0-500 volts at 0.5" to the surface being measured, and 0-3,000 volts at 4". The high range measures 0-5,000 volts at a distance of 0.5" and 0-30,000 volts at 4". For repetitive measurements, keep ACL-300 has a "quick zero" function which instantly zeroes the instrument and provides ground compensation for the user.

FEATURE SUMMARY

- a. Measures static charges from zero to 30,000 volts
- b. Designed for close, repetitive readings.
- c. Completely self-contained.
- d. Multiple ranges.
- e. Repeatability $\pm 1\%$; accuracy $\pm 10\%$.
- f. Quick-Zero function.

Tools

RECOMMENDED TOOLS

The following Recommended Tool List is to guide the site prep engineer in ordering tools and test equipment. Before purchasing any tool not on the list, please contact PRSD Service Engineering. Many considerations were taken into account before the listed tools were picked.

Call the vendor to obtain a price and delivery date. Some vendors offer quantity discounts.

Note that there are two recommended Tool Kit vendors. They have similar tools. These vendors will provide their own catalogs, on request.

Where a HP Purchase Agreement Number is listed, be sure to refer to it when ordering, to ensure you receive the standard HP configuration.

Some tools and test equipment may not be available in some countries. In such cases, contact your ICON support representative or Support Engineering at PRSD in the U.S.

Tools

TOOL	VENDOR(s)
HI-3004 Field Strength Meter	Holaday Industries, Inc.
Sierra 251-2 Air Particulate Sampler	Anderson Sampler, Inc.
ACL 300 Electrostatic Meter	ACL, Jensen, Marshall
Dranetz 626 Disturbance Analyzer	Dranetz Technologies, Inc.
HP 4329A High Resistance Meter	HP
Simpson Model 474 Digital Multimeter	Marshall, Metermaster, Jensen
Beckman Model 330 Digital Multimeter	Marshall, Metermaster, Jensen
HP 3561A Dynamic Signal Analyzer	HP
JTK-535 Prep/Power Tool Kit	Jensen Tools Inc.
MCM-1166 Site Prep Tool Kit	Marshall Claude Michael
ECOS Tools (B7106,1020I,1023)	Ecos Electronics Co.
Oneac Line Viewer (LV103)	Jensen Tool, Inc.

Tools

TOOL: HI-3004 FIELD STRENGTH METER

FUNCTION: RFI Measurement

PURCHASE AGREEMENT NUMBER: 122

**PURCHASE FROM: Holaday Industries, Inc
14825 Martin Drive
Eden Prairie, MN 55344**

**PHONE NUMBER: (612) 934-4920
TELEX 29-0922**

**LIST OF PARTS: HI-3004 Field Strength Meter
Nicad Battery Option
HI-3110 Modified Recorder Output**

TOOL: SIERRA 251-2 AIR PARTICULATE SAMPLER

FUNCTION: Air Particulate Measurement

PURCHASE AGREEMENT NUMBER: 120

PURCHASE FROM: Anderson Sampler, Inc
4215 Wendell Drive
Atlanta, Georgia 30336

PHONE NUMBER: (404) 691-1910

LIST OF PARTS: None

Tools

TOOL: PARTICULATE FILTER

FUNCTION: Level of Particulate Measurement

PURCHASE AGREEMENT NUMBER: Not Applicable

PURCHASE FROM: Galston Technical Services, Inc.
6601 Kirkville Road
East Syracuse, N.Y. 13057

PHONE NUMBER: (315) 432-0506

LIST OF PARTS: HP-GR Filter

NOTE: Filters are tested by Falston and require a properly completed form. Forms are normally available from the HP regional environmental specialists.

TOOL: ACL 300 ELECTROSTATIC METER

FUNCTION: ESD Static Measurement

PURCHASE AGREEMENT NUMBER: 118

PURCHASE FROM: ACL Incorporated
1960 East Devor Avenue
Elk Grove Village, IL 60007

PHONE NUMBER: (312) 981-9212
TELEX 433-0251

CONTACT: Kim Becker or Jim Warren

INTERNATIONAL DISTRIBUTORS

BELGIUM
Chemelec Intl S.A.
Rue Paul Lauters 65
1050 Bruxelles Belgium
Phone: (02) 640 27 00
Telex: 23815
Mr. Barry Gassner

CANADA
Canlabs
80 Jutland Road
Toronto, Ontario
M8Z 2H4 Canada
Phone: 416 252-5151
Mr. Bob Wilson

ISRAEL
Arka Electronics Ltd.
32 Hanatziv Street
Tel Aviv, Israel
Telex: 341128
Mr. Gil Shvitlovski

ENGLAND
Kempston Electrical
Shirley Road Rushden
Northamptonshire
NN10 9BZ England
Phone: Rushden4351
Telex: 311249
Mr. Basil Kennard

FRANCE
Gentec Sarl
Centre D'Affaires-Paris
La Bonaparte
93153 Le Blanc Mesnil
Telex: 213363

JAPAN
TDK, Electronics Co., LTD.
13-1, 1-chome, Nihonbashi
Chuo-Ku, Tokyo 103 Japan
Phone: (03)278-5072
Telex: J24270

SCANDINAVIA
Scandec
N-1820 Spydeberg
Norway
Phone: (02)887480
Telex: 19203
Mr. Rolf Reierskog

TAIWAN
Taipei Formosa
Tex Chu Trading Co
Telex: 10907
Phone: 351-5123
Mr. Wang
President

This meter may also be ordered from Jenson and Marshall Claude Michael.

Tools

TOOL: DRANETZ 626 DISTURBANCE ANALYZER

FUNCTION: Power Monitor and Analyzer

PURCHASE AGREEMENT NUMBER: 626-HP

**PURCHASE FROM: Dranetz Technologies, Inc
1000 New Durham Rd., CN-91
Edison, New Jersey 08818**

**PHONE NUMBER (201) 287-3680
TWX: 710-997-9553
TELEX: 499-7808**

HP Configuration List of Parts:

- 1. 626 W/101 MF Mainframe**
- 2. 626-PA-6003 Three Phase Module**
- 3. 106725 Shipping Container**

Options: (order as required)

**626-PA-6008 Temperature and Humidity Module
626-PA-6002A1 Low Range DC Module
626-PA-6006-1 AC Neutral Ground Module**

Tools

TOOL: HP 4329A HIGH RESISTANCE METER

FUNCTION: Measure Carpet Resistance

PURCHASE AGREEMENT NUMBER: Not Applicable

PURCHASE FROM: Hewlett-Packard

**LIST OF PARTS: HP 4329A High Resistance Meter
16008A Resistivity Cell**

Tools

TOOL: SIMPSON MODEL 474 DIGITAL MULTIMETER

FUNCTION: All Electrical Measurements

PURCHASE AGREEMENT NUMBER: Not Applicable

PURCHASE FROM: Any Metermaster, Simpson Distributor, Jensen Tools,
or Marshall Claude Michael.

FEATURES:

1. 4.5 Digit Accuracy
2. Continuity Tester (audio)
3. >500 VAC
4. <400 VDC
5. Diode Check
6. >10 Meg. In. Res.

TOOL: BECKMAN 330 DIGITAL MULTIMETER

FUNCTION: Measuring True RMS Voltage and Current during Site Prep

PURCHASE AGREEMENT: None

PURCHASE FROM: Marshall Claude Michael
Phone: Outside Calif 1-800-432-4186
In Calif (818) 442-7204

Jensen Tools Phone (602) 968-6231
Metermaster Phone (213) 685-4340

LIST OF PARTS: Beckman 330 DMM

RECOMMENDED OPTIONS:
DC0205 Deluxe Carrying Case
CT-234A Current Probe
BC047 True RMS Conversion Adapter

Tools

TOOL: HP 3561A DYNAMIC SIGNAL ANALYZER

FUNCTION: Vibration Measurement

PURCHASE AGREEMENT NUMBER: Not Applicable

PURCHASE FROM: HP Instrument Sales should be contacted for help.

NOTE: Contact peripheral divisions for their product vibration specifications.

LIST OF PARTS: 3561A Signal Analyzer
Option 001 Bubble Memory

TOOL: JTK-535 PREP/POWER TOOL KIT U.S.
 JTK-535 PREP/POWER TOOL KIT European

FUNCTION: Tools for Site Prep / Power Testing

PURCHASE AGREEMENT NUMBER: Not Applicable

PURCHASE FROM: Jensen Tools, Inc.
 7815 So. 46th St.
 Phoenix, Arizona 85040
 Phone: (602) 968-6231

LIST OF PARTS:	Mirror, Telescoping	69B102
	Penlight	221B100
	Adjustable Wrench, 8"	92B208
	Universal Hexdriver	185B525
	Screwdriver with Tips	36B425
	Measuring Tape, 25-foot,	
	Inches and Metric Scales	195B038
	Tile Puller, 3-1/4" Cup	570B825
	Diagonal Cutter, 5"	1B005
	Long Nose Pliers with Cutter, 6"	1B001
	Screwdriver, 5/16 x 6"	36B566
	Pallet	54B127
	Case ("Super Tough")	377B617
	Accu Test (ECOS 7106)	469B716
	Current Meter (Amp Probe RS-3)	483B303
	Sling Psychrometer	566B013
	Outlet Tester (Tension)	777B508
	Protective Spectacles (glasses)	204B010

Tools

TOOL: MCM-1166 SITE PREP TOOL KIT U.S.
MCM-1166A SITE PREP TOOL KIT EUROPEAN

FUNCTION: Site Prep Tool Kit

PURCHASE AGREEMENT NUMBER: Not Applicable

PURCHASE FROM: Marshall Claude Michael
Addresses follow

LIST OF PARTS:

PART NUMBER	DESCRIPTION
A-3825	Tile Puller
RS-3	Current Probe
12-7013	Sling psychrometer12-7013
D78P	8" Adjustable wrench
7106	Accutest ground check
9215WB-E	Penlight w/push-button top
37937-6	Screwdriver w/four bits
PPB1814-4-4-3-032	Black poly case w/1 pallet w/dividers
33-428	25' Tape measure
61-125	Hex-a-matic nutdriver
A-2T-TK	Telescopic Inspection mirror
41-5C-TK	5" Diagonal cutting pliers
654-6C-TK	6" Long chain nose pliers
R-5166-TK	5/16" X 6" Slotted screwdriver
SG29C	Protective spectacles

MARSHALL CLAUDE MICHAEL ADDRESSES

For information outside California: Phone: 1-800-432-4186
For information inside California : Phone: 818-442-7204

ATLANTA DIVISION
4350J International Blvd.
Norcross, GA 30093
(404) 9251895 CMG-Linda Hastings, SM

DAYTON DIVISION
6212 Executive Blvd.
Dayton, OH 45424
(513) 236-8112 CMG-Jeff Young, RM

AUSTIN DIVISION
8705 Shoal Creek Blvd. #202
Austin, TX 78758
(512) 458-5654 CMG-Henk van Empel, GM
Austin Warehouse: 8711 Burnet Rd. #H-96
Austin, TX 78758

DENVER DIVISION
7000 North Brodaway
Denver, CO 80221
(303)427-1800 CMG-Roger Lindsay, GM

BINGHAMPTON DIVISION
10 Hooper Road

FT. LAUDERDALE Sales Office
1001 NW 62nd Street, #306D

Dec 86; Internal Only
5-48

Endwell, NY 13760
(607) 754-1570 MEG-Keith French, GM

BOSTON DIVISION
One Wilshire Road
Burlington, MA 01803
(617) 272-8200 CMG-Ken Rubino, GM

CHICAGO DIVISION
1261 Wiley Road, #f
Schaumburg, IL 60195
(312) 490-0755 CMG-Jerry Jerik, GM

CLEVELAND DIVISION
5905B Harper Road
Solon, OH 44139
(216) 248-4165 CMG-Gary Kremer, SM

CONNECTICUT DIVISION
20 Sterling Drive, Barnes Ind Park, N.
P.O. Box 200
Wallingford, CT 06492
(203) 265-3822 CMG-Dick Bentley, RM

DALLAS DIVISION
14205 Proton Road
Dallas, TX 75234
(214) 233-7650 CMG-Charlie Maclin, GM

LONG ISLAND DIVISION
275 Oser Avenue
Hauppauge, LI, NY 11788
(516) 273-1515 CMG-Barbara Atchinson, GM

LOS ANGELES DIVISION
8015 Deering Avenue
Canoga Park, CA 91304
(818) 999-6570 CMG-Louie Liuag, RM

MARSHALL INDUST, CORP HQ
9674 Telstar Avenue
El Monte, CA 91731-3004
(818) 442-7204 CMG/MEG

MARSHALL INDUST, "TOOL KITS"
5250 Whisperwood Lane
Indianapolis, IN 46226
(317) 547-8808 CMG-Dave Hackenbruch, SM

MARYLAND DIVISION
8445 Helgerman CT.
Gaithersburg, MD 20877
(301) 840-0228 CMG-Walter Marple, GM

Ft. Lauderdale, FL 33309
(305) 928-0661 CMG-Joe Griffith, SM

HOUSTON DIVISION
3698 Westchase Drive
Houston, TX 77042
(713) 789-9300 CMG-Bill Carroll, GM

HUNTSVILLE DIVISION
3313 Memorial Parkway South
Huntsville, AL 35801
(205) 881-9235 CMG-Don Thomas, GM

INDIANAPOLIS DIVISION
6990 Corporate Drive
Indianapolis, IN 46278
(317) 297-0483

IRVINE DIVISION
17321 Murphy Avenue
Irvine, CA 92714
(714) 660-0278 CMG-George Plescher

KANSAS CITY DIVISION
8321 Melrose Drive
Lenexa, KS 66214
(913) 492-3121 CMG-Bill Loeschner

PHILADELPHIA DIVISION
102 Gaither Drive
Mt. Laurel, NJ 08054
(609) 778-8720 CMG-Bill Balkenhol GM

PHOENIX DIVISION
835 West 22nd St.
Tempe, Az 85282
(602) 968-6161 MEG-Chuck Haas, GM

PITTSBURGH SALES OFFICE
701 Alpha Drive #240
Pittsburgh, PA 15238
(412) 963-0441

RALEIGH DIVISION
5221 North Blvd.
Raleigh, NC 27604
(919) 876-7383 CMG-Jim Hearn, GM

ROCHESTER DIVISION
1280 Scottsville Rd
Rochester, NY 14264
(716) 235-7620 MEG-Ron Schroeder, GM

Tools

MICHIGAN DIVISION
13760 Merriman Road
Livonia, MI 48150
(313)525-5850 MEG-Gary Bidus,GM

MILWAUKEE SALES OFFICE
235 North Executive Dr. #305
Brookfield, WI 53005
(414)797-8400 CMG

MINNEAPOLIS DIVISION
3800 Annapolis Lane
Plymouth MN 55441

SACRAMENTO DIVISION
3039 Kilgore Avenue #140
Rancho Cordova, CA 95670
(916)635-9700 MEG-Nick Goldey,SM

SALT LAKE CITY SALES OFFICE
3501 South Main Street
Salt Lake City, UT 84115
(801) 261-0901 MEG

SAN DIEGO DIVISION
10515 Carroll Canyon Road
San Diego, CA 92131

TOOL: ECOS TOOLS

FUNCTION: Various Site Prep Grounding test tools

PURCHASE AGREEMENT NUMBER: Not Applicable

PURCHASE FROM: ECOS Electronics Company
205 West Harrison Street
Oak Park, Ill 60304

Phone # (312) 383-2505

POWER ADAPTERS:

Model #	Plug #	Type
AL5-20	L5-20	Locking
A6-30	6-30	
AL-30	L6-30	Locking
AL14-20	L14-20	Locking
AL21-20	L21-20	Locking
AL21-30	L21-30	Locking

AK-HP HP adapter kit with all of above

Model #	Description
B7106	Accutest (1 ohm)
7552	Hardwired Equipment Probe
7561	Neutral/Ground Reversal Probe
7562	Isolated Ground Test Probe
7563	36" Mini-extension Cord
7564	Neutral Impedance Adapter
7565	Remote Ground Probe
7566	Field Calibration Reference
7706A	Soft-side Zipper pouch
BSK-B	Kit of probes listed above
TP-2	Same as BSK-B without B7106 and 7566

10201 Ground Impedance Tester (Single Phase)

1023 POW-R-MATE (Three Phase)

2300 Earth Ground Tester
The 2300 is used very rarely; it should be ordered with discretion.

Tools

TOOL: ONEAC LINE VIEWER

FUNCTION: Use to view AC power disturbances on an oscilloscope.
Strips the AC component and displays DC components.

PURCHASE AGREEMENT NUMBER: Not Applicable

PURCHASE FROM: Jensen Tools, Incorporated
7815 So. 46th Street
Phoenix, Arizona 85040
Phone number: 602-968-6231

LIST OF PARTS: LV 103

Comes in a case with two probes, power cord and instruction manual.



QUESTIONS AND ANSWERS

APPENDIX

A

This appendix answers common site prep CE questions about policy and procedure.

Q: Can I refuse to authorize installation at a site that doesn't meet our recommended specs?

A: No. A properly prepared site is not a prerequisite for installation. If, after hearing about the benefits of a properly prepared site, the customer still decides against it, HP must still install the system. There is only one situation where you can refuse installation; that is where the site is unsafe, it presents a hazard to your health. Also, you are cautioned against trying to make a decision about "refusing installation" yourself. Get your district manager involved immediately if such a situation arises.

Q: Okay, I have to authorize installation if the site doesn't meet our recommended specs. Can I withhold a warranty?

A: No. HP warrants its hardware against defects in material and workmanship for 90 days, regardless of site conditions. However, the warranty does not cover failures caused by sites that do not meet our recommended specs. Charge the customer time and material rates for repair work caused by such failures. The answer above about getting your district manager involved applies here too.

Q: So if the site doesn't meet our recommended specs, I can't refuse installation and I can't withhold a warranty. Can I deny a maintenance contract?

A: Technically yes, but don't even think about doing that on your own. The idea is to help the customer understand that the recommendations help her get maximum reliability from her computer. If you have tried your best to make her understand that, and she still doesn't want to (or can't) meet the recommended specs, don't paint yourself into a "You can't have a contract" corner. Get your district manager involved.

Q: Why don't we ban carpeting?

A: "No carpeting" is not an HP spec. We "strongly discourage" it because it increases ESD potential, as well as trapping lint, dirt, tobacco smoke and ashes, etc. Nevertheless, we cannot demand that the customer remove carpeting any more than we can demand he not smoke near the computer, or demand he paint the walls pink, or tell him what wine to order with his lobster. If he wants carpeting,

Questions and Answers

even though you've warned him of the dangers, it's his decision to make.

Q: Sometimes customers ask me why HP places so much emphasis on site preparation, when "Other computer companies don't require any site prep". What's going on?

A: Don't believe everything you hear. Virtually all other large computer companies have site prep specs just like ours, but sometimes, maybe, the word doesn't reach everyone who should know. Some of our best sales success stories started with customers who weren't urged to solve their environmental problems before installing a competitor's system. Our approach is that the customer is better served by solving the site problems before the computer is installed.

Q: I keep hearing that our products are getting more "bullet proof". Does this mean some day there won't be any need for site preparation?

A: It's possible, because HP manufacturing divisions are spending piles of money making their products less susceptible to electrical and environmental problems. However, there will very likely always be some areas of the world where power, for example, will remain unacceptable for computers. The Fort Lauderdale, Florida, office reports that in a recent survey of 100 computer sites (potential and existing), not a single one had acceptable power. Not one. Similarly, CEs in Denver say virtually every (large frame) HP 3000 site in the area needs a line conditioner to meet the recommended specs. As another example, in many parts of the world, winter humidity drops so low that ESD becomes an extreme problem if proper air conditioning/humidity control isn't maintained. Only time will tell if the majority of computer products can be made so bullet proof these conditions can be disregarded.

Q: In the CSSA and its Exhibits, we state that after installation, we will monitor the customer's environment "periodically". How often is periodically?

A: During scheduled visits, the Account CE may review the site based on failure history, system interruptions or new equipment added to the system.

Q: Can I establish a policy requiring all customers in my district to install power line conditioners, without testing each site individually?

A: No. The power at each site must be monitored to verify that it needs conditioning. However, it is possible that all sites in your district will in fact need line conditioning to meet HP's recommended specs.

ESCALATION PROCEDURES

APPENDIX

B

This appendix describes a site environment escalation procedure that was prepared by a committee of field, factory, and PRSD representatives. The first part, "Problem Escalation", suggests steps if a customer, knowing the advantages of a site that meets HP's recommended specs, still decides not to (or cannot) meet them. The second part, "When Add-Ons are Expected", suggests an approach the site prep CE or Account CE should take when the customer's current system meets the recommended specs, but the customer plans to later add a weaker link component (one with a tighter spec).

PROBLEM ESCALATION

The following steps are suggested when the site prep CE has notified the District CE Manager (DCEM) that the customer does not want to, or cannot, modify his site to meet HP's recommended specs, but still wants a Customer Support Services Agreement (CSSA).

(1) The DCEM should contact the customer to discuss the benefits of operating within HP's recommended specs vs. operating outside them. The DCEM and the customer should evaluate alternative modifications, cost of modifications, uptime requirements, cost of downtime, permanency of site, cost of time and material service, cost of contractual support, and other relevant issues. In many cases, the customer and DCEM will agree on whether modifying the site is a good business decision.

It is anticipated that at least 95 percent of all problem situations will be resolved at or before Step 1. In the remaining five percent of cases, if the customer decides not to modify the site but still requests a service contract, the DCEM should notify the Area CE Manager (ACEM).

(2) The ACEM should evaluate providing the customer with a "support special". The adverse effects of some environmental conditions can sometimes be minimized or eliminated through more frequent periodic maintenance (PM) and predictive maintenance than is standard. If the ACEM determines that acceptable uptime levels can be maintained through increased preventive or predictive maintenance, a support special may be proposed.

Site conditions, projected number of PMs, projected number of failures, and any other relevant issues should be considered in determining the price and terms of the special. To ensure consistency among support specials, all specials must be approved at PRSD.

Escalation Procedures

(3) If a support special is impractical, the system will be supported only on a time and material basis. The ACEM should send a letter to the customer explaining the reason for the CSSA ineligibility or termination.

WHEN ADD-ONS ARE EXPECTED

This paragraph suggests an approach for the CE when the site presently meets the weakest link spec for the system to be installed (or presently installed), but the customer plans to later add a component with tighter specs.

The CE should determine that the recommended specs are being met with the customer's current components (or components to be installed). The "system level" specs are determined by the system's weakest link component (the one with the tightest specs). The CE should write the customer a letter explaining that the site meets HP's recommended specs only for the current configuration, and that site modifications may be necessary if and when a component with tighter specs is added to the system.

DIRTY POWER AND SOLUTIONS

APPENDIX

C

This appendix describes how power that's clean when it leaves the power company gets dirty by the time it arrives at the customer's computer. It also describes the major types of line treatment devices used to clean the dirty power, and suggests guidelines for the customer's use when analyzing vendor spec sheets. The information in this appendix was researched by the PRSD Lab. It has been updated and expanded from a 1982 four-part series of *Support Update* articles.

OVERVIEW

One of the most troublesome and destructive problems facing the computer industry today is inadequate power. Line voltage fluctuations, transients, and high frequency noise fed into an unprotected system through its power cords greatly affect its performance. This appendix provides an understanding of power transmission, noise generation, power susceptibility of computer systems, and power correction/noise reduction devices. The first Paragraphs describe how power is transmitted, then define noise and other power problems and show how they get onto power lines.

CLEAN POWER TRANSMISSION

Electric power is a function of voltage and current (measured in amperes). The two common definitions of power, Real Power and Apparent Power, are derived from the following equations:

Apparent Power, in Volt-Amps (VA) = VI

Real Power, In Watts = $VI \cos \theta$

where V = voltage in volts

I = current in amperes

$\cos \theta$ = Power Factor (≤ 1)

θ = angle between V and I

Electric power is generated many ways. The generation plant can be compared with a vast ocean of power that must be channeled to the consumer in the most efficient way. These channels are electrical conductors which, unfortunately, have inherent impedance. AC power, once generated by the electric company, is distributed to customers as shown in Figure C-1.

Transmitting power over long distances at high voltages and low currents is beneficial as it requires much smaller conductors than

Dirty Power and Solutions

high current, low voltage transmission, minimizing losses to impedance as well as conductor expense. This is the main reason step-up transformers are used at the plant to increase the voltage to 345kv or higher. Step-down transformers are then used to obtain voltages for industrial, commercial, and residential use.

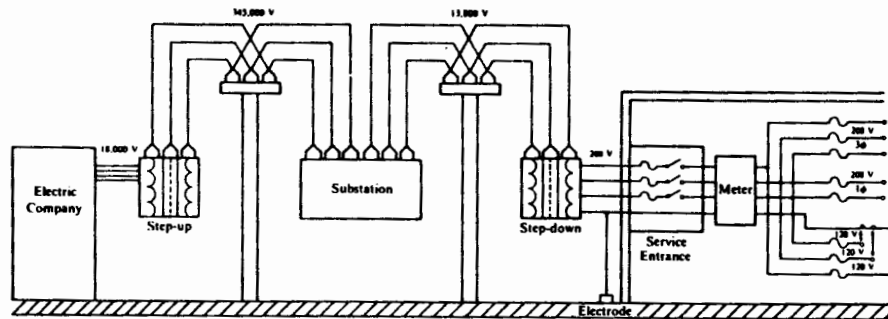


Figure C-1. Typical Three-Phase Distribution

In this configuration power can be transmitted to the user in an efficient manner. The trouble is, however, that the clean sine waves generated at the plant are seldom, if ever, clean sine waves by the time they reach the users' site. This "dirtying" of the power is examined next.

DIRTY POWER TRANSMISSION

For this discussion of how clean power gets dirty, some terms are defined as follows:

Dirty Power - power which differs from a pure sine wave due to distortion from noise and/or voltage anomalies.

Noise - any high frequency (above about 10kHz) voltages of varying amplitudes which distort the pure AC wave. Included are impulses, both ringing and exponential decay; and low voltage continuous waveforms.

Common Mode Noise - noise appearing in relatively equal proportion both on the line (or lines in multiphase) and neutral with respect to ground reference.

Normal Mode Noise - noise appearing on the line (or neutral) with respect to the neutral (or line). Normal mode noise could also

Dirty Power and Solutions

appear on one or more phases of a multiphase system with respect to another phase.

Voltage Anomalies - fluctuations in the 50 or 60 Hz sine wave. Included are sags, surges, brownouts, and blackouts.

Frequency Distortion - any variance in frequency from the generated frequency.

Many things can alter the power from the time it is generated to the time it is used by the consumer. As shown in Figure C-1, there are at least seven places where noise or voltage fluctuations can enter the power system. These are described next.

Electric Company (Power Plant)

Once power is generated at the plant, two major control processes are implemented. The first is line/load regulation. Power companies are required by law to deliver nominal voltages to users with only small variations. On occasion the company must reduce the line voltage below this level (causing a brownout) in order to handle an extreme load such as occurs on hot summer days. These brownouts are usually announced in advance, yet must still be dealt with at the user's site. Also to be considered is the event of equipment failure at the plant, causing unannounced brownouts or blackouts for varying lengths of time.

The second major process at the plant involves correcting the power factor. Power is generated and transmitted most efficiently when the voltage and current are in phase. Due to reactive loads using the power, a power factor equal to 1 is not always possible. The majority of loads causing this problem are inductive, so correction of the situation involves switching large capacitive, in or out of the power system to offset the result of the inductive reactance. This switching can cause large impulses to be introduced into the transmission system which can then propagate to the consumer.

Step-Up Transformers

Figures C-2 and C-3 show typical step-up transformers in Wye-Delta configurations.

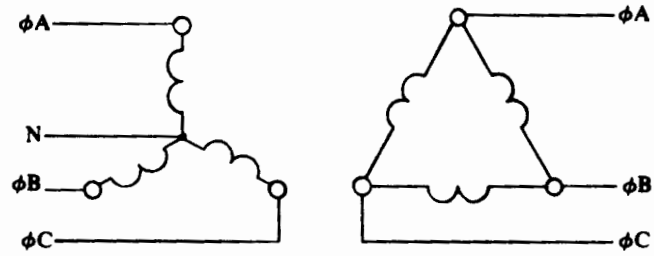


Figure C-2. Standard Three-Phase Transformer, Wye-Delta

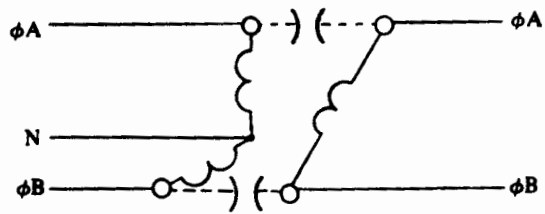


Figure C-3. One Phase of Three-Phase Wye-Delta, with Coupling Capacitance

Dirty Power and Solutions

It is important to recognize that a power transformer is designed to work at 50 or 60 Hz, not high frequencies. Even though it may not generate dirty power itself, the transformer may transfer it to a high voltage line. This is because common mode noise from the power generation plant can be passed through the transformer by the coupling capacitance of its primary and secondary windings. A normal mode pulse will then be induced onto the secondary windings, probably at a higher voltage.

Transmission Lines

As previously described, power is channeled through conductive wires with inherent impedances. Figure C-4 shows how these wires function electrically.

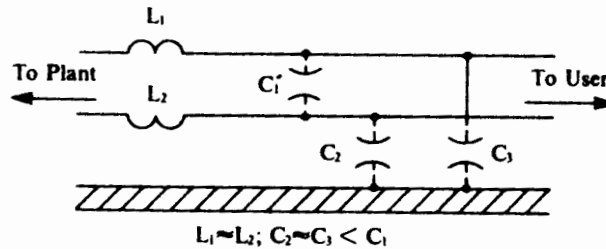


Figure C-4. Wires and Impedances

The impedance of inductors and capacitors depends on the frequency, as shown in the following equations:

$$X_L = 2(\pi)fL$$

$$X_C = 1/2(\pi)fC$$

Estimates of L and C for transmission lines are: 1 mH of series inductance per mile and 0.027 uF of shunt capacitance per mile at foot spacing. So, at 50 or 60 Hz, X is quite small (~ 0.4) and X_C is quite large (100k). However, when frequencies begin to exceed 10 kHz or so, X_L increases and X_C decreases. In effect, the design of the transmission line and the choice of low frequency power distribution greatly enhance high frequency noise rejection.

The difficulty is that $C(1)$ is much greater than $C(2)$ or $C(3)$. There is some attenuation of common mode noise by $L(1)$ and $L(2)$, as well as slight discharging by $C(2)$ and $C(3)$, but it is still quite

present on the line. Normal mode noise may also be blocked and discharged somewhat, but most of the normal mode noise will be coupled to the other line (or lines) and converted to common mode noise. Therefore, it is inevitable that the transmission lines become normal to common mode noise converters.

Worse still is the fact that these lines are run over long distances and are subject to external interference. This interference may come from lightning, communication signals, or even electronic auto ignition systems. The result is that the transmission lines act as common mode noise receivers since all the lines are subject to the same interference. Generally then, although there is natural filtering of some noise problems in transmission lines, they still receive and conduct common mode noise to the user.

Substations

Substations are used to tap power from the main distribution lines and prepare it for customer use. The voltage is generally reduced, but still kept high enough to minimize the losses. Figure C-1 shows the 345 kV main being tapped and reduced to 13,800 volts by the substation Delta-Delta step-down transformer. Common mode noise is again coupled through the transformer to the secondary output. Also, in order to tap off the main, connections must be made from the lines, to the transformers, and then back to other transmission lines. Each of these connections have the potential to allow ground faults or open circuits which may add various types of voltage anomalies to the lines. So although the substation is necessary for power transmission, it also helps dirty the power.

Transmission to User

The power must now be distributed to customers from the substation. The type of transmission used here is the same as described in the preceding paragraph on Transmission Lines. The analysis used there is relevant here for showing what can happen from the substation to the step-down transformer near the consumer.

Step-Down Transformer and Service Entrance

Once the power is transmitted from the substation it travels to the consumer. For this description we will assume the consumer is a commercial site and the step-down transformer is a 13.8 kV to 208 V, three-phase, Delta to Wye configuration, as shown in Figure C-1. At this stage a neutral conductor is derived from the Wye configuration. This neutral is grounded or earthed to provide a zero volt reference and ensure safety in the event of any ground faults or shorts. Figure C-5 shows a single phase of this three phase transformer with an electrical schematic of a ground connection.

Dirty Power and Solutions

On the primary side there will be mainly common mode noise. This noise should be coupled to the secondary in the form of normal mode noise with reference to the neutral since the neutral is grounded. However, due to the phase-neutral coupling on the secondary and the primary to secondary coupling, common mode currents will be generated in the secondary which will flow to ground through the grounding conductor. This will generate a voltage across L equal to $L(di/dt)$. This voltage will be seen on the neutral and coupled to the phase conductors creating common mode noise. Thus, although the step down transformer should (and in fact does) convert common mode noise to normal mode, common mode noise is still generated and passed into the service entrance.

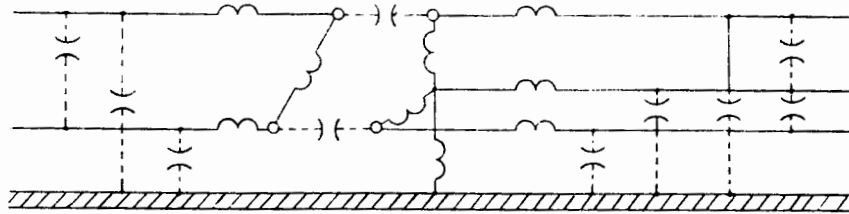


Figure C-5. One Phase of Three-Phase Transformer, with Ground

Internal Power Problems

All equipment in the building is subjected to common mode and normal mode noise, as well as various voltage anomalies, all of which are generated external to the building. Within the building, however, more problems occur to further dirty the power. Heavy motor loads, such as machinery or air conditioning compressors, can easily cause sags and surges in the voltage.

Fluorescent lights and copying machines often add low voltage noise to the power. Arc welders and other machinery requiring large amounts of current for short time periods generate normal and common mode impulses. Security transceivers ("walkie talkies") and even automatic coffee makers have been known to cause problems. These possible disturbances will only add to the problems already on the line when it enters the building.

So far we have seen that dirty power is the result of external and internal disturbances which distort the AC sine wave. Situations

may occur where the external or the internal power may be relatively clean, but usually at least one will be dirty enough to require a power line treatment device. Certainly neither of these will get better in the future. As more and more distribution networks reach maximum capability, and as long as power is transmitted by wires, dirty power will have to be cleaned up for computer use.

INTRODUCTION TO LINE TREATMENT DEVICES

Thus far we have defined dirty power and identified some of its sources, both external and internal to the computer user's site. We showed how power generated at the electric company could contain common and normal mode noise, waveform distortion, and various voltage anomalies by the time it reached the customer. As the demands on power plants increase, available system power will continue to degrade. Now we will look at how dirty power can disrupt computer equipment operation and will define the techniques and technologies available to clean up power problems.

Though computer equipment is made up of a vast complexity of analog and digital devices, the most power sensitive devices are the integrated circuit (IC) chips. These ICs, and all data transmissions between them, require very precise DC voltages and currents. Even slight deviations from these voltages and currents can result in garbled (or lost) data, malfunctioning logic, or even IC destruction.

To see how externally-generated AC power can affect the computer's DC voltage (and thus its reliability) we will examine what happens at the interface between the AC and DC, the power supply. Two types of computer power supplies are common: linear and switching supplies (see Figures C-6 and C-7). They are named for the regulation technique each employs to maintain a constant DC output voltage.

Linear supplies use power transistors operating in the linear region as variable series resistances. The output DC is regulated by controlling these transistors.

Switching supplies use power transistors as switches. These switches generate a pulse train, usually about 20 kHz, which is transformed and rectified to produce DC voltage. Regulation is achieved by adjusting the duty cycle of each transistor. How these supplies respond to dirty power will be discussed next.

Figures C-6 and C-7 show that the AC power will be rectified before being applied to the regulating elements. Voltage fluctuations appearing at the input will still be present in some degree after rectification. Although the regulating elements are designed to maintain a constant output, there are voltage levels which cannot be adequately regulated due to their wide variance in amplitude or duration from nominal.



Dirty Power and Solutions

These fluctuations, if a powerfail is detected on the incoming peak AC, could result in unwanted system shutdowns or failures in data transmission. Powerfail detect circuitry sensing the unregulated DC is less susceptible to waveform distortion, but still subject to these conditions.

High energy impulses coming from the line may damage components and disrupt operation of the power supply, or may be passed directly to the DC voltage buses, causing system malfunction. Common mode noise in particular could cause the DC voltages to jump with respect to signal ground (most of HP's equipment connects power ground to signal ground) which will garble data and scramble logic commands. A dirty ground may intensify this effect and increase system downtime.

In addition, exposed or non-isolated leads within the power supply are able to act as antennas and radiate noise into the equipment cabinet where it can be picked up by data lines, printed circuit traces, and chip leads, again disrupting proper operation. Notice that in all of these possible events there is very little isolation at the chip level from noise and voltage problems. Any disturbance which passes through the supply may cause undesirable downtime, reduce component life expectancy, or if large enough, even damage some components.

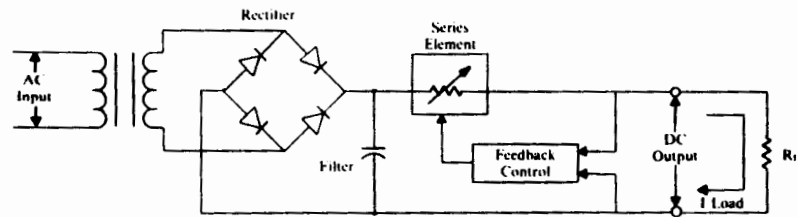


Figure C-6. Linear Power Supply

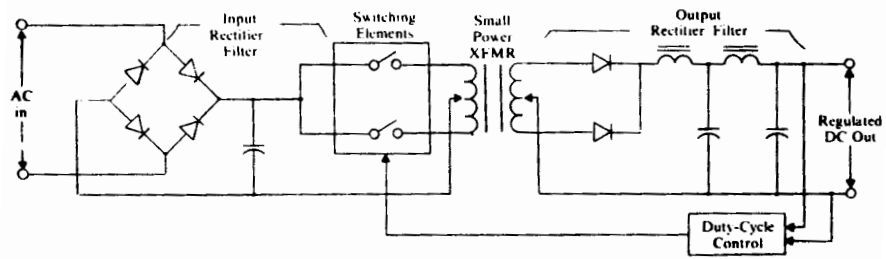


Figure C-7. Switching Power Supply

Dirty Power and Solutions

In the attempt to create computer grade power and provide maximum uptime, new techniques and technologies have been designed. Some of these are internal to the computer equipment. Other computers contain power supplies that are designed to handle a wider tolerance of input voltages. The majority of work, however, has been aimed at providing external strategies and devices to reduce problems before they reach the computer equipment. The next paragraphs will examine these techniques.

POWER CLEANING TECHNIQUES

One of the most common techniques for minimizing noise is to install a dedicated service and isolated ground for the system. "Dedicated" means no other device is powered from the same wires as the computer equipment. This reduces the affects of other loads in the building on the computer system, including voltage anomalies, load imbalances, or conducted noise.

An isolated ground is a conductor connected as close as possible to the service entrance ground and kept from any electrical connections except those of the computer equipment. This grounding method reduces the affect other loads can create, and minimizes the threat of ground loop currents disrupting the system. As mentioned previously, a clean ground increases the equipment's immunity to noise on the power lines.

Another technique is shielding. Shielding is commonly used to protect against radiated Electromagnetic Interference (EMI). EMI induces noise in exposed conductors such as power cords or data cables. Proper shielding of these prevents EMI from affecting the power or data transmission.

Dedicated power lines, isolated ground, and shielding all help to isolate the computer system from the problems associated with dirty power. But in many cases they are not enough. Some form of external device may be required to clean up (isolate and/or regulate) the power. Modern technologies vary from small transient suppressors to large Uninterruptable Power Supply (UPS) systems. The following Paragraphs describe nine major categories of line treatment devices.

Transient Suppressors

Transient suppressors (see Figure C-8) are known by many names, including Metal Oxide Varistors (MOVs), gas tube varistors, and avalanche diodes. Basically, a transient suppressing device is placed in parallel with the computer load and senses either voltage or current spikes with fast rise times. These spikes are then either clamped at a preset level or diverted from the load to ground. Some devices have components in series with (as well as parallel to) the load.

In either case, the usefulness of the device is measured by its ability to discharge energy out of the system and not just divert it to another, perhaps more critical part of the system. For example, discharging a normal mode spike from hot to neutral may create common mode noise. Also, diverting a large surge current to ground may create a voltage potential due to the ground conductor impedance and thus common mode noise on the hot and neutral. Again, the prime concern is energy dissipation, not just voltage clamping or current diversion.

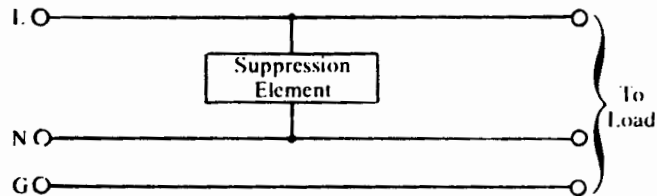


Figure C-8. Typical Parallel Suppressor

Filters

There is a gray area in definition between suppressors and filters. Generally, filters have passive RLC networks to attenuate high frequency noise. They are used where low energy noise must be stripped from the AC line. This type of noise may never reach the clamping levels of suppressors, but can cause just as many problems. In many cases, however, filters are also necessary to prevent system generated noise from going back out on the power lines which may violate FCC, VDE, or other regulations.

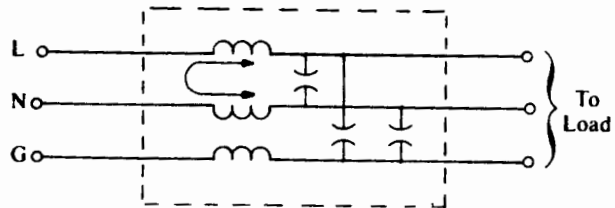


Figure C-9. Low Pass Filter with Common Mode Choke

Isolation Transformers

Isolation transformers became useful to the computer industry to step voltages up or down and help prevent ground loops. As computer equipment became more sensitive to noise, the isolation transformer's inherent ability to block common mode noise made it desirable. Shielding of the primary from the secondary increases the common mode noise rejection by decreasing the interwinding coupling capacitance. Thus a key factor in considering an isolation transformer is its coupling capacitance. Note that an isolation transformer alone offers very little normal mode noise rejection.

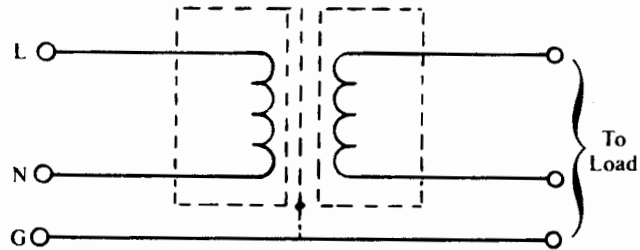


Figure C-10. Triple-Shielded Isolation Transformer

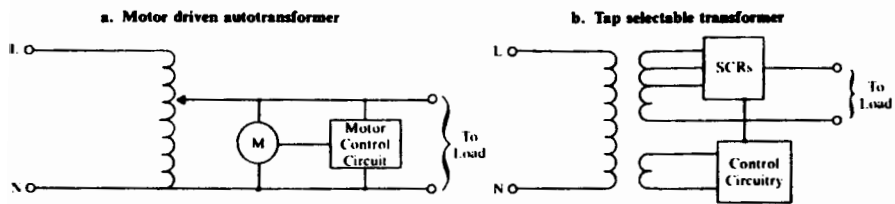


Figure C-11. Two Types of Voltage Regulators

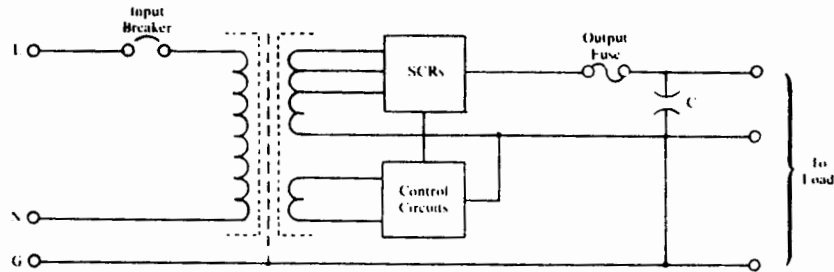


Figure C-12. Triple-Shielded, Tap-Switching Line Conditioner

Voltage Regulators

Voltage regulators are intended to combat voltage fluctuations. A voltage regulator may be designed around electronics or a transformer. Given a nominal input voltage which may vary as much as $\pm 20\%$, a voltage regulator will provide a nominal output voltage with a variance of $\pm 1\%$ or better. They will usually respond within 1-5 cycles of detection of the voltage fluctuation. The output voltage bandwidth due to varying line and load conditions and the response time are the main factors to consider for voltage regulators.

Tap Switching Line Conditioners

Line conditioners in general provide both isolation and regulation. However, they provide no protection from line dropouts. A tap switching line conditioner is a combination of an isolation transformer and a transformer based regulator. Faraday shields around and between the primary and secondary transformer windings provide the isolation. Electronically controlled SCRs or triacs, switching between winding taps on either the primary or secondary, provide regulation. Usually there is some form of filtering to achieve normal mode noise rejection.

The percentage of a tap switcher's output regulation depends on the number of taps and the desired input range. They are switched on either the voltage or current zero crossing and there must be enough difference between the sensing levels to prevent oscillations between taps (tap dancing) should the input voltage be exactly at

the switching level. Important factors for tap switching line conditioners include line and load regulation, response time, coupling capacitance, and normal mode noise rejection.

Ferroresonant Line Conditioners

Ferros represent another approach to power line treatment using transformers. A ferroresonant transformer operates by saturating the core at voltages much lower than nominal. This, in effect, chops off the top of the voltage waveform. This clipping eliminates any transient common and normal mode noise, and allows for wide input voltage variation with very small output change. The peaks of the wave are reconstructed to minimize waveform distortion. Thus the ferro has very good noise isolation and voltage regulation.

It has very poor load regulation, however, and must usually be operated at 40-60% of full load when handling equipment that produces large surge currents (discs, printers, etc.). A ferroresonant line conditioner is less efficient, noisier, and heavier than an isolation transformer or tap switching line conditioner of comparable rating. Key considerations for ferroresonant line conditioners include steady state current of equipment, amount of load imbalance, and required efficiency.

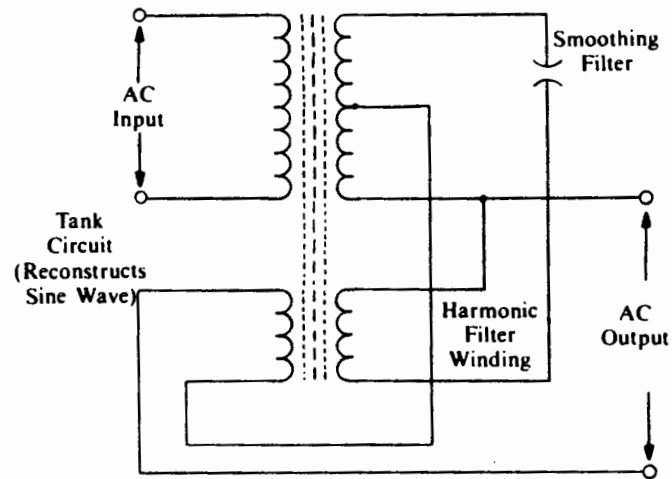


Figure C-13. Typical Ferroresonant Transformer

Combinational Line Conditioners

'Combinational' is an ambiguous name referring to devices which isolate and regulate, but are neither tap switching nor ferroresonant. They are instead some combination of the others. An example would be a transient suppressor, filter and regulator in one unit. A device such as this may not clean up the line enough, depending on the severity of the power problems.

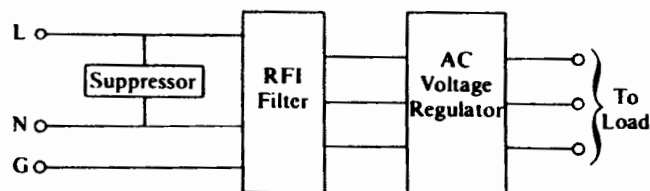


Figure C-14. Combinational Line Conditioner Example

Motor Generators

In this category, AC input runs a motor which turns a generator and produces the AC for the load. A large flywheel of some kind is usually spun to provide mass inertia for continued generator rotation if the input voltage should drop out. Since the interaction between the motor and generator is strictly mechanical, there is complete electrical isolation. A motor generator (see Figure C-15) provides excellent isolation, good regulation, and short term ridethrough. It is important to consider the cost benefits of ridethrough and the frequency variances resulting when the power drops out momentarily. Most motor generator sets will lose synchronous 50 or 60 Hz operation while operating off the flywheel.

Dirty Power and Solutions

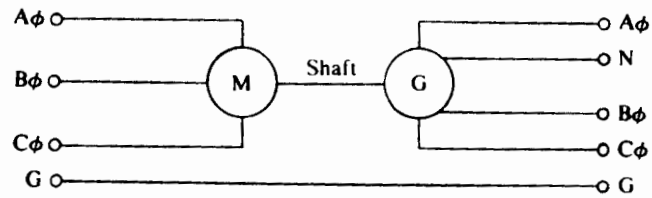


Figure C-15. Three-Phase Motor Generator

Uninterruptible Power Sources

An Uninterruptible Power Source (UPS) is the ultimate isolation from AC power problems. It provides isolation, regulation, ridethrough, and blackout protection. UPS systems generally provide battery backup for short term outages and connections to a diesel generator for long term outages. For any situation where consistent and continuous power is mandatory, a UPS should be considered. Keep in mind, however, that they are generally very expensive, require a great deal of space, and are very heavy. See Figure C-16.

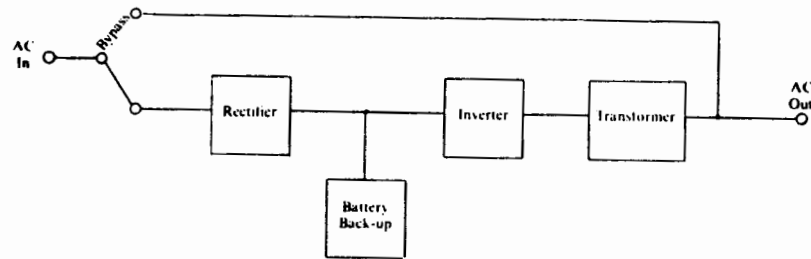


Figure C-16. Typical UPS with Battery Back-Up

The preceding line treatment devices are not mutually exclusive. Many devices use several technologies in one unit. Others may not seem to quite fit under any group heading; nevertheless the majority can be placed in at least one category.

The descriptions for each group were necessarily brief. A more detailed analysis of two major types of line conditioners begins in the next Paragraph. They are the only ones analyzed in detail for two reasons: first, they are the two most often suggested in the field; second, they generally employ an isolation and a regulation technology already described. For example, a look at tap switching line conditioners must involve examination of isolation transformers and tap selectable regulators. Included in each line conditioner description will be things to look for when selecting a device, as well as how to read vendor spec sheets.

TAP SWITCHING LINE CONDITIONERS

Preceding paragraphs in this Appendix described how noise, voltage fluctuations, and other anomalies distort AC power and make it inadequate for computer use. Subsequent paragraphs showed how this dirty power affects computer equipment uptime and examined various techniques and technologies in power line treatment. The following paragraphs analyze one of these technologies -- the tap switching line conditioner.

A tap switching line conditioner combines the isolation of an isolation transformer with the regulation of a tap-selectable voltage regulator. To fully understand a tap switcher's operation,

isolation transformers, tap switching regulators, and their interaction are described. This is followed by a look at the overall performance of these devices.

Isolation Transformers

An isolation transformer is a device which physically separates a circuit while maintaining electrical continuity. This allows cancellation of ground loop currents while giving the user an opportunity to attenuate noise before it enters the computer power lines. An isolation transformer consists of a magnetic core on which are primary and secondary windings. Figure C-17 shows a schematic of a typical isolation transformer.

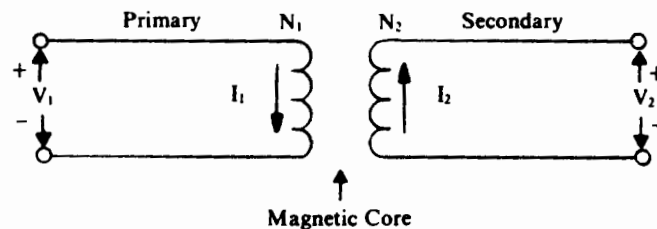


Figure C-17. Typical Isolation Transformer

As current (I_1) flows in the primary side, it generates a magnetic field. Faraday's Law states that a current is induced in a wire which is located in a changing magnetic field. This is what happens in the secondary of the transformer. Since I_1 is an alternating current, the magnetic field it generates is alternating also. This induces the current I_2 in the secondary winding. V_2 and I_2 are related as shown in the following equations:

$$V_2 = V_1(N_2/N_1)$$

$$I_2 = I_1(N_1/N_2)$$

where N = Number of turns

AC power, therefore, is transmitted through an isolation transformer by generating a changing magnetic field which induces power onto the secondary.

A corollary to Faraday's Law states that if there is no change in the magnetic field, no current can be induced. This fact results in an isolation transformer's inherent common mode noise rejection. A common pulse appears on both transformer input lines simultaneously, so there is no change in the magnetic field and thus no induced power in the secondary. Conversely, a normal mode pulse, which appears between two lines, will cause a change in the field and thus be seen on the secondary. Since the inductance of the primary and secondary windings is directly proportional to frequency, this pulse will encounter a higher impedance and be somewhat blocked.

These ideal characteristics of excellent common mode noise rejection and minimal normal mode noise rejection are altered in an actual isolation transformer due to the "phantom" coupling capacitances between the primary and secondary windings. There is no physical capacitor, but there is the electrical effect of one.

This capacitance will pass high frequency common mode and normal mode noise to the secondary in the form of normal mode noise. Shielding the primary from the secondary greatly reduces the coupling capacitance, and placing a box shield around the primary and another around the secondary provides more than enough isolation from noise.

Figure C-18 shows a triple shielded isolation transformer with a typical coupling capacitance of 0.005 pF or less. The shields in this configuration are tied to ground whereas some other configurations refer the primary shield to input neutral and the other shields to ground. The grounding scheme varies from one device to the next. For safety reasons the ground must be carried through an isolation transformer used for computer equipment. This eliminates the protection from ground loop currents, but enhances the noise rejection.

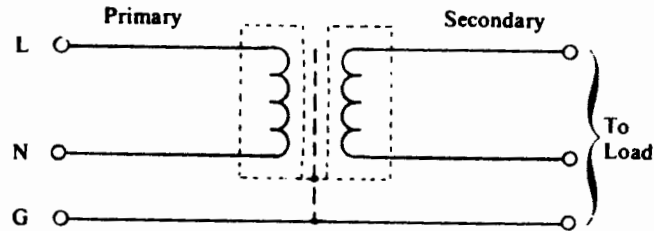


Figure C-18. Triple-Shielded Isolation Transformer

Tap Switching Voltage Regulation

A tap selectable regulator uses a transformer with multiple connections on either the primary or secondary. These connections allow for changing the effective turns ratio of the windings. Recall that the turns ratio determines the output voltage. By selecting different ratios the output voltage can be regulated. The bandwidth of regulation depends on the number of taps and the range of input voltages to be regulated. See Figure C-19.

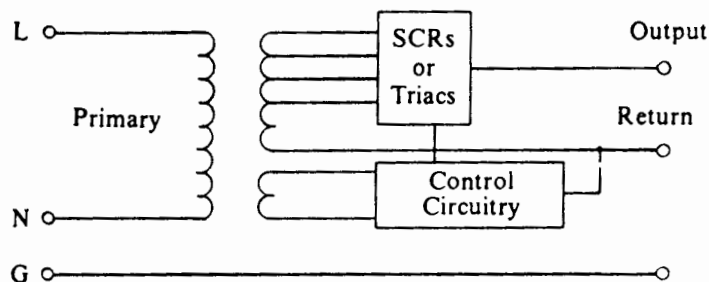


Figure C-19. Tap Switchable Voltage Regulator

A tap will change when the control circuitry detects a voltage which exceeds the tap threshold. The circuitry usually monitors every half cycle and will change tap if necessary, regulating at the next half cycle providing a typical response of one cycle. The triacs or SCRs used should be turned on at the zero voltage or zero current crossing to minimize switching-induced impulses. It is also important that no two elements be on simultaneously.

To prevent oscillating between two taps in the event the voltage is exactly at a threshold, there is an overlap designed into the sensing circuitry. The threshold to change to a lower tap is generally one to two volts less than that to change back to the higher tap. For example a change is made from one tap to a lower tap when the input voltage has fallen to 110 volts. In order to return to the first tap, the input voltage must rise to 112 volts. This eliminates "tap dancing" due to small voltage fluctuations.

Isolation + Regulation = Line Conditioning

Since the tap selectable regulator is designed to use a transformer it can easily be combined with an isolation transformer to produce a noise rejecting, voltage regulating, line conditioner. Figure C-20 shows that shielding the regulator provides the essential common mode noise rejection, and placing a low pass filter on the output gives normal mode noise attenuation.

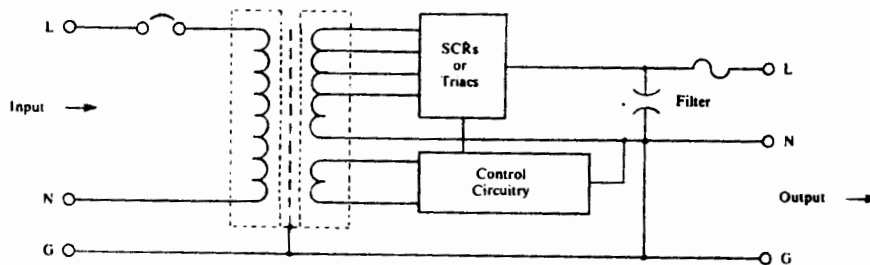


Figure C-20. Tap Switching Line Conditioner

Most tap switchers have a circuit breaker on the input and a fuse on the output for overcurrent protection. HP equipment normally requires operation on a grounded electrical system. This implies the need for a ground to neutral bonding jumper to reference the new AC source.

The preceding paragraphs described the basic concepts behind the operation of a tap switching line conditioner. In theory, a tap switcher should provide very good protection from a dirty power line; however, there are strengths and weaknesses associated with tap switchers in various situations. The most important aspects of tap switcher performance are described next.

Noise Rejection

Shielded isolation transformers attenuate noise, provided the frequency of the unwanted noise falls below certain limits. Capacitors, real for normal mode and phantom for common mode, tend to break down at high frequencies. Impedance versus frequency for capacitors is not linear at all frequencies, so what may reject very well at 100 kHz may do very poorly at 100 MHz. Generally tap switchers provide good noise attenuation up to 1 MHz then tend to degrade. Many manufacturers include suppressors on the input of some models to add further noise suppression.

A noise-free ground increases a computer's immunity to other problems. Usually at least one shield of the transformer is connected to the dedicated ground. Since shields not only prevent

noise between windings but also can radiate noise to the windings, care must be taken in grounding the case or the shields to minimize the potential for radiating the building's ground noise onto the secondary of the transformer.

Regulation

Tap switching line conditioners provide a consistent output within a particular bandwidth. The limits of the bandwidth are within the requirements for computer equipment, and the typical one cycle response time adequately prevents unwanted shutdowns. An area, however, that has not been fully examined is the output bandwidth. Must the output voltage be held stable with only slowly-varying changes, or is it acceptable for voltage to bounce around as long as it remains in the acceptable output range?

For example, say an output voltage between 110 and 120 is within the computer's specs. If the input voltage is at a tap threshold and is subject to many sags below 110 volts, the output voltage will be switching from 110 to 120 volts and back again repeatedly. The affects of this repeated switching are not known.

Reliability

Since the regulating capability of a tap switcher depends on many electronic components, each subject to failure, reliability becomes an issue. Long operating life is obviously desired and, as much as possible, is designed in, but failures may still occur more often than is considered tolerable. Servicing cost and repair time are issues which must be considered when choosing to use a tap switcher.

Inrush Capability

Large startup currents and high, intermittent, operating currents generated by computer equipment are often neglected when considering a line treatment device. These are later resolved by providing sequential startup procedures or underloading the device so that it might handle the given currents. Tap switchers can work well with current surges as high as 500% of full load current. For complete system startup after powerfail shut down, surge currents of this size or greater can be seen, and most switchers have been found to handle them without failure.

Current Starving

A condition not addressed by many tap switcher suppliers involves the device's interaction between the AC power and the computer equipment. Due to the prevalence of switching power supplies, operating currents are no longer transferred to the equipment in a

Dirty Power and Solutions

sinusoidal wave but rather as a series of spikes. Figure C-21 shows a typical waveform from a switching power supply.

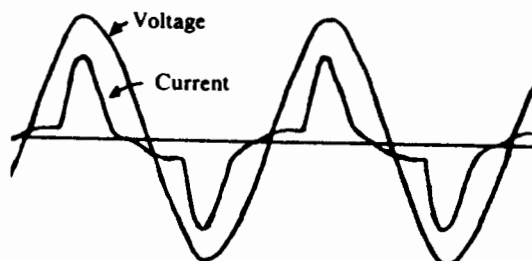


Figure C-21. Switching Power Supply Current and Voltage Waveforms

Although the current alternates at 50 or 60 Hz, the fast rise times of the spike are equivalent to 500 Hz to 1 kHz. When sinusoidal 50 or 60 Hz current is required by the computer, it wants a low impedance path to the AC source through the line treatment device. When a current spike is required, however, the computer perceives a much higher impedance to the AC source. The current therefore, is actually harder for the computer to get resulting in a current starving condition. If sufficient current is not available at the computer when it is required, undesirable voltage sags or waveform distortion can occur.

Waveform Distortion

In the preceding description of transformers, it was shown that the output current is directly affected by the changing magnetic field. The more current required by a computer system, the closer the magnetic core will be driven to saturation. This means that the magnetic field begins to oppose change, creating output voltage and current distortion (seen as a clipping of the waveforms). Usually the transformers are sufficiently oversized by design to keep this from occurring under normal load.

The possible clipping of the waveforms described above is in addition to any distortion already present on the line. The total can cause problems in the regulation process if the computer senses peak levels for powerfail, while the line conditioning device senses average levels. What may appear as a low voltage powerfail condition to the computer may not be viewed by the line conditioner as low enough to cause a tap change.

SELECTION CRITERIA

There are three major criteria to consider when choosing a tap switching line conditioner: noise attenuation, power, and operating characteristics.

NOISE ATTENUATION

To understand noise rejection, decibels must be understood. Noise attenuation specs, rated in decibels (dB), are usually based on the following equation and the circuits in Figure C-22.

$$\text{dB} = 20 \log(V_{\text{in}}/V_{\text{out}})$$

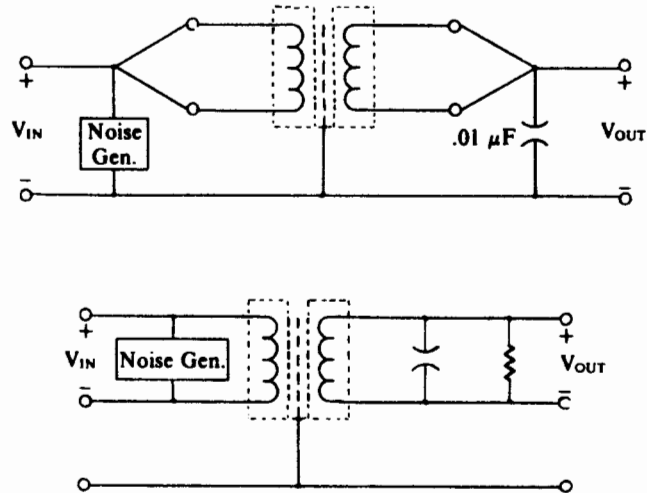


Figure C-22. Rejection Tests: Common Mode Top; Normal Mode Bottom

Common Mode Noise

The common mode noise rejection spec is found by injecting AC voltage onto the shorted primary of the transformer alone and measuring output voltage across a 0.01 uF capacitor. These two readings use the preceding equation to derive the dB rating. This test should be done over a range of frequencies since the noise attenuation is dependent on frequencies. The noise spec should give this frequency range and the lowest dB rating over that range.

Thus, a common mode noise rejection figure of 120 dB for 10 Hz to 1 MHz means that over this entire frequency span the input voltage was one million times the output. Not bad, if the typical computer system were a 0.01 uF capacitor. This size capacitor is supposed to represent a computer load, yet not every vendor agrees on this. One

may use 0.01 and another 1 uF and claim the same rating while one obviously has better rejection. See Figure C-23 and the two equations following it.

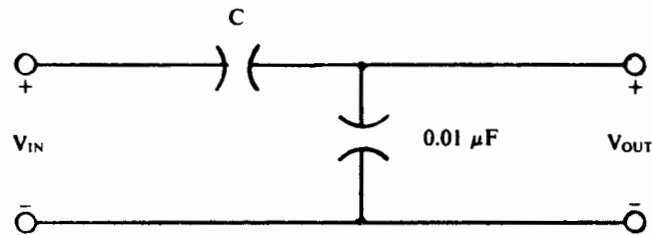


Figure C-23. Coupling Capacitance in Common Mode Noise Rejection Test

$$C = (V_{out} \cdot 0.01 \mu F) / (V_{in} - V_{out}), \text{ or}$$

$$C = 0.01 \mu F (V_{out} / V_{in}) \text{ where } V_{in} \gg V_{out}$$

By considering the coupling capacitance C , confusion due to various load capacitors can be eliminated. In the example of 120 dB rejection, C would equal .01pF. If the load capacitor was 1 microFarad in the test, but the specs read that CMNR = 120 dB, the coupling capacitance would be 1pF. So, if two spec sheets give similar CMNR ratios, check the coupling capacitance. The device with the lower coupling capacitance offers better rejection.

Normal Mode Noise

Normal mode noise rejection ratings are found using a circuit like the one in Figure C-22, bottom. A resistive load is placed on the output and AC voltages are injected in the primary side. The output voltage is measured after the filter and dB rating are determined.

The spec sheets generally will specify the value, a resistive load, and the frequency at which the test was conducted. This is usually 100 kHz. Problems that arise with using this information are that an unrealistic load may have been used or frequency range may not have been given. The vendors would have to be questioned to get more information on this since no other specs relate to normal mode noise rejection.

POWER CRITERIA

Characteristics used to judge the power of a tap switching line conditioner include input and output voltage, efficiency, the power rating, and the power factor.

Input and Output Voltage

Input and output voltages appear in spec sheets either as ranges (e.g., 96 to 138 volts), or as percentage deviations from nominal (e.g., +15%, -20%). Voltage ranges are easier to understand since the nominal voltages vary from one site to the next. The number of taps can be determined with the following equation:

$$\text{Taps} = [(\text{high input} - \text{low input}) / (\text{high output} - \text{low output})] + 1$$

After rounding off to the nearest whole number, one tap will be selected to provide the proper turns ratio for regulation.

Efficiency

Efficiency is the ratio of input power to output power and is given as a percentage in the equation:

$$\% \text{ Efficiency} = (\text{power out} / \text{power in}) * 100$$

It will always be less than 100 percent, but should be at least 90 percent, regardless of load.

Power Rating

A tap switcher is sized by its output kilo volt-amp (kVA) load. Its rating is based on output voltage and current. Vendor specs state the KVA magnitude and possibly a nominal output voltage. The important information is the maximum steady state input current required for operation. This is necessary to provide proper installation capacity and prevent overloading the device. The maximum (single phase) current is found using the equation:

$$\text{Maximum Current} = (\text{rated kVA} * 1000) / \text{Minimum Input Voltage}$$

Power Factor

In reactive loads, there is a phase angle between volt and current. The cosine of this phase angle is known as the power factor and is less than or equal to one. Some vendors recommend that their device be operated within certain power factor limitations. HP equipment usually operates well within the vendors' specifications.



OPERATING CHARACTERISTICS

This topic covers many of the specs that relate to the actual operation of the unit. Some specs are self-explanatory. Others require explanation.

Distortion

If this spec is given, it is usually presented as a percentage of Total Harmonic Distortion (THD). Some vendors use THD as "Third Harmonic Distortion" in order to print a lower spec, but most mean "Total". The percentage is the amount of deviation the sum of the harmonics adds to sine wave. What the specs don't say is where the distortion was measured (input or output) and under what load. The specs will always be given in terms of percent added to the distortion already on the line.

Response Time

The response time is the time the device takes to correct for a voltage anomaly. It is found by sensing a half cycle and adjusting one tap for the next half cycle. This gives the typical one cycle response. If the voltage problem exceeds the limits of one tap correction, another tap is selected at the third half cycle. The specs are given, though, for a single tap correction.

Surge Rating or Overload

Surge specs are usually given as a percentage overload for a specified time duration. This is an important spec if the computer system has high start-up or surge currents. The ratings given are "over load", meaning the amount above rated current. For example : a 100% overload of a 20 amp device would be 40 amps.

The duration is given for the amount of time the maximum current state can be withstood without tripping the circuit breaker or damaging the transformer. The one cycle rating is most important for high inrush currents and should be considered in selecting the line conditioner. Many times the inrush requirements of HP equipment exceed the vendor's specs. If this happens, the vendor can be requested to verify complete operation at a higher inrush current.

Before ordering a tap switching line conditioner, consideration should also be given to such things as flexibility, convenience, startup versus expansion costs, etc.. Vendors offer a wide variety of options ranging from the "no frills" basic model to the "anything goes" type with distribution cables, separate circuit breakers, complete power monitoring with alarms, and more. Some of these options may benefit the customer.

FERRORESONANT LINE CONDITIONERS

The following paragraphs continue to describe power line conditioners, with an examination of ferroresonant transformers. The theory behind ferros is described, followed by an analysis of how they work on dirty power. Information on how to interpret vendors' spec sheets follows; then options available on ferros are identified.

A ferroresonant line conditioner is designed around a ferromagnetic core as shown in Figure 24.

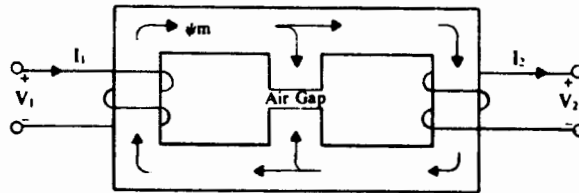


Figure C-24. Ferromagnetic Core of Ferroresonant Transformer

As current I_1 flows through the primary it generates a magnetic field and magnetic flux in the core. Most transformers operate in the mode where a change in the current causes a change in the flux and thus a change in the induced current I_2 . Note that, due to the magnetic properties of the transformer core, there is a point where the flux produced reaches a maximum density and the core is said to be saturated. A large change in current then causes a very small change in the flux and thus a small change in the secondary current.

This saturation of the core is avoided in isolation transformers, whereas ferroresonant transformers are specifically designed to function in this range. As I_1 increases, the flux increases and is forced to the secondary since the air gap has a higher reluctance (magnetic impedance) than the secondary. Soon the flux is at a maximum and the core is saturated. I_1 , however, continues to increase.

Forcing the flux beyond the saturation point could magnetically damage the core, so the reluctance of the secondary is designed to be much greater than that of the air gap at the point of saturation. This gives the damaging flux a return path through the gap as opposed to the secondary windings. The saturation level is

therefore maintained in the secondary and the output voltage is kept somewhat constant over a wide input voltage range. This produces flat-topping of the output voltage as shown in Figure C-25.

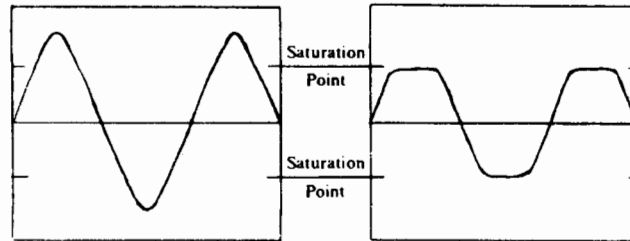


Figure C-25. Ferro Flat-Topping: Input Left, Output Right

This type of power is unacceptable for computer systems due to the varying voltage levels still possible and the large amount of clipping of the waveform. The voltage problem is solved by adding another winding, called compensating winding, to the secondary. The winding is connected to the secondary such that it opposes the changes in flux which cause the small changes in output voltage. This provides a more stable output voltage, though the waveform is still distorted by flat-topping.

The waveform can be restored to a sine wave by regenerating its top half and adding it to a stable output. This is achieved by adding a neutralizing winding and a capacitor to the secondary as shown in Figure C-26.

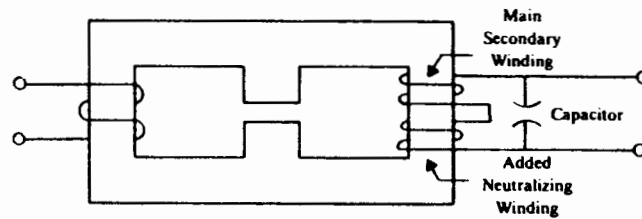


Figure C-26. Ferro with Winding and Capacitor on Secondary

As the flux through the winding increases, the inductive reactance also increases. At the saturation point, the inductive reactance equals the capacitive reactance, creating a parallel resonating circuit. This circuit is designed to resonate at the same frequency as the nominal input frequency. The output voltage of this winding is an oscillating sine wave with peak amplitudes greater than those available from the turns ratio alone.

Since the neutralizing winding is connected in series, adding to the main output, two things happen. First, the resonance helps increase the magnetic reluctance of the secondary. This maintains saturation in the secondary and allows an air gap to be a "safety valve" for any damaging flux. Second, the output of the waveform is recreated to be a sine wave from the stored energy in the resonating circuit, and the resonating harmonic frequencies help reduce the overall harmonic distortion of the waveform.

Remember that the original input voltage is chopped off by the main secondary windings, so any noise or voltage anomalies which exceed the voltage level of saturation are absorbed by the core and are not transferred to the output. A schematic of the transformer is shown in Figure C-27, and the affect of the different windings is shown in Figure C-28.

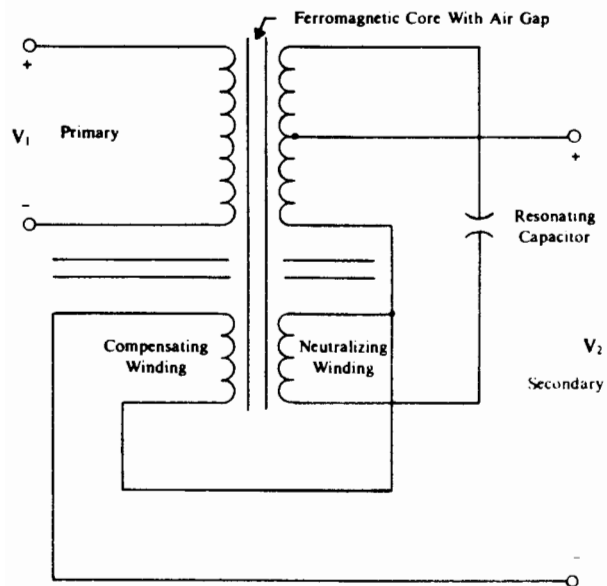


Figure C-27. Ferroresonant Transformer

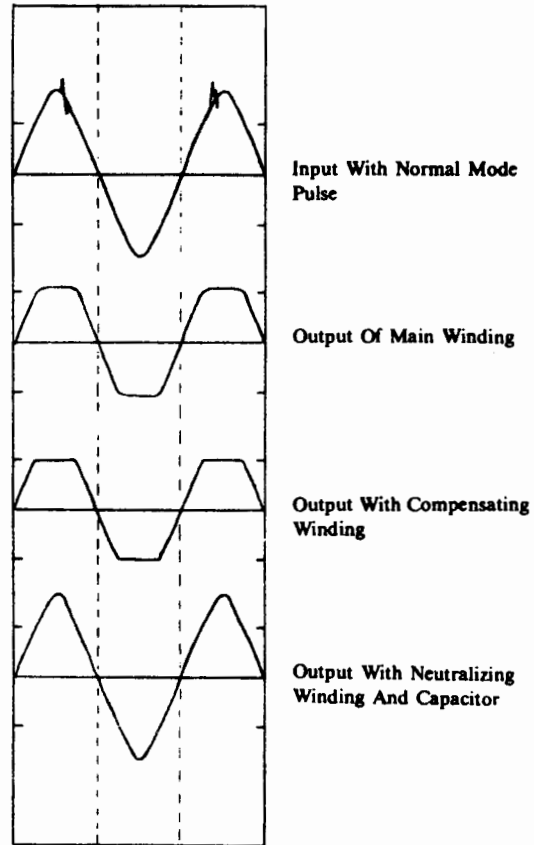


Figure C-28. Affects of Different Ferro Transformer Windings

The design of the ferroresonant transformer provides very good noise rejection and voltage regulation. Again, however, shielding must be provided to achieve good common mode noise rejection due to the coupling capacitance between the coils. There are four windings, and each should have a shield that is tied to ground. Figure C-29 shows a ferroresonant line conditioner that provides noise rejection and voltage regulation.

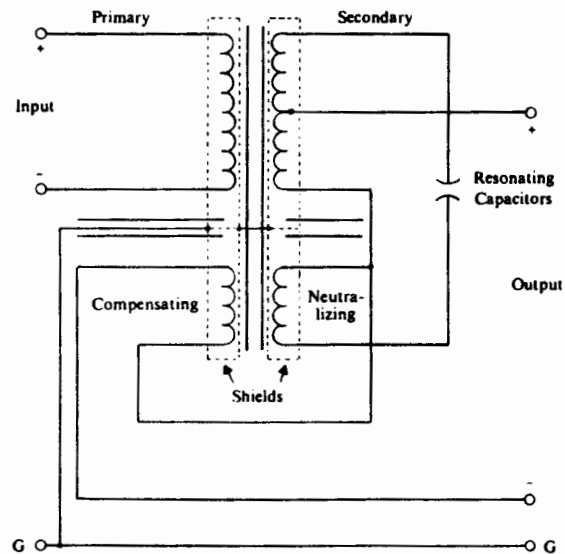


Figure C-29. Ferroresonant Line Conditioner with Noise Rejection and Voltage Regulation

From the preceding explanation, it might appear that the ferro is an exceptional line conditioner. Practically speaking, however, its performance cannot always match the ideal. The following paragraphs describe ferro performance in six categories. They are the same categories used to describe tap switchers, so comparisons can be made.

Noise Rejection

Recall from the theory of a ferroresonant transformer that its magnetic core operates in saturation. Once saturation occurs, all noise and voltage anomalies appearing within the saturation region are absorbed by the core and do not affect the output. Normal mode noise is eliminated by this absorption. Common mode noise will not change the magnetic field, as the shields prevent it from being coupled onto the secondary, so it too is greatly attenuated.

Regulation

There are no taps in a ferroresonant line conditioner, so the output voltage does not jump between wide tolerances. For slow varying voltages the ferro will regulate extremely well maintaining a linear output bandwidth. For transient problems, such as sags or surges, or fast load changes the flux density may be affected. In these cases the output voltage may take 8 to 50 msec to adjust back into regulation, the typical response being one cycle (~ 17 msec).

An important fact to remember is that the ferro's resonating frequency and thus its output voltage, depends on the input frequency. If the input frequency varies, the output voltage varies to an even greater extent. Typically, a 1% change in input frequency will result in a 1.5% change output voltage. This can be quite a problem in sites where unstable frequency is common.

Reliability

Reliability is one of the ferros' strong points, as they have no sensitive electronic components. Some devices are fan-cooled, but the fans are also reliable. Despite a lack of components subject to failure there is an important area of the transformer design that should be mentioned here. If, in any way, the width of the air gap (or gaps) internal to the device is altered the operation of the ferro is extremely degraded. If the unit is dropped or severely bumped it could become non-functional. With proper care in installation and use, a ferroresonant line conditioner should be very reliable.

Inrush Capability

A ferroresonant line conditioner is a current limiting device usually rated at 150% overload. This means that the device will not allow the output current to exceed 150% of nominal output current. Whenever this condition arises the unit will respond by dropping the voltage to zero. After a short time interval, roughly 50 to 100 msec, the unit will attempt to bring the voltage back up.

When using a ferro with computer equipment, particularly discs, printers, or tape drives, this current limiting poses a problem. Inrush currents can easily be 500% over steady state load for a computer system. Disc access currents or printing currents add up to 100% over nominal. If a ferro is operating at full load when disc is spinning up, or if the entire system is attempting to recover from a powerfail, the 150% spec could be exceeded forcing the output voltage to zero.

When the ferro tries to bring the voltage back up, it will experience the same start-up currents, which will force it to zero volts again and again. This oscillation could continue until a human intervenes.

For this reason it is recommended that ferros be operated between 40% and 60% of rated full load. A ferro with a 150% spec at full load has an equivalent rating of 250% at 60% load. This should handle small surge currents. Undermining this solution, however, is the fact that the lower the applied load, the lower the unit's efficiency. A ferro rated at 90% efficiency at full load may only be 65% efficient at 50% of full load. This will affect the heat output and required input power, which are described in the following paragraphs.

Current Starving

Ferroresonant line conditioners, like tap switching line conditioners, are subject to current starving. Refer to the previous Paragraph on Tap Switching Line Conditioners . . . Current Starving, for a description of this condition.

Waveform Distortion

Recall that a ferroresonant transformer chops the top of an AC sine wave, then regulates it with a resonating circuit. In theory, this can produce a relatively distortion-free waveform. However, consideration must be given to factors which can disrupt the sine wave. If the input frequency or load power factor is out of spec, distortion increases. Lowering the percentage of load also increases distortion. Acceptable distortion can usually be obtained by maintaining these factors.

ANALYZING VENDOR SPECIFICATION SHEETS

Vendor spec sheets sometimes contain little detail or explanation. The following paragraphs clarify some specs that commonly appear in vendor spec sheets.

Noise Attenuation

Most ferro vendors specify their common and normal mode rejections in terms of dB according to the equation:

$$\text{dB} = 20 \log (V_{\text{in}}/V_{\text{out}})$$

Common mode rejection is achieved in a similar manner with ferros as previously described with tap switchers. A common mode pulse does not change the magnetic field so it is not induced onto the secondary. Shielding reduces the effective coupling capacitance so the noise is not coupled onto the secondary either. Common mode noise rejection figures of 80 to 120 dB are standard for ferros. This is an important factor for ferros as well as tap switchers since their transformers reject common mode noise.

Normal mode noise is attenuated more than common mode in a ferroresonant line conditioner. This is the opposite function of tap switchers. Since the ferro operates in saturation, the added flux a normal mode produces is absorbed by the core without inducing the pulse onto the secondary. Ratings of 120 dB are common for normal mode noise rejection.

Power Regulation

A ferro can accept a wide input voltage range and still maintain a small output voltage bandwidth. The specification sheets will show allowed percentages from nominal voltage (both input and output) and may give a voltage range. For slow varying changes in the input voltage the output is linear across the entire output range. Large sags or surges, sudden load changes, short term dropouts, or other transient events, may force the output out of range temporarily. In these cases the response time of the ferro must be known to calculate how soon the output will back in spec. Remember that output regulation depends on input frequency and will only be as stable as that frequency.

Power Efficiency

Efficiency is determined by the equation:

$$\% \text{ Efficiency} = (\text{Power out} / \text{Power in}) * 100$$

A ferro's efficiency is entirely load dependent, so the best efficiency is at full load. This is typically 85 to 90 percent. Recall, though, that a ferro should only be loaded to 40 to 60 percent for computers, to leave capacity for inrush and surge currents. Efficiencies with 40 to 60 percent loads are approximately 60 to 70 percent. Lower efficiencies mean some input power is lost within the device; this lost power becomes heat. The lost power means more input power is required, and the heat generated may affect the customer's air conditioning needs.

Power Rating

Ferros, like tap switchers, are rated for power in units of Volt-Amps (VA). The VA rating is the product of the steady state output voltage and current. When counseling the customer about sizing a ferroresonant line conditioner, however, the load percentage and the projected efficiency must also be considered. For example, assume a computer system uses 20 amps at 120 volts. Assume the system has several discs; thus its desired load rating is 60 percent, which yields a 70 percent efficiency. The system, then, needs a 4.0 kVA line conditioner, as shown by the equation:

$$\text{Output kVA} = (\text{Nom V} * \text{Nom I}) / \text{Load rating}$$

The efficiency rating is also used to size the input circuit breakers and wiring. In the preceding example, 4 kVA is needed at the output of the ferro, but 5.7 kVA is needed at the input, as shown by the equation:

$$\text{Input kVA} = (\text{Output kVA}) / \text{Efficiency}$$

Frequency and Distortion

The frequency spec severely limits the input frequency range to ensure that the output voltage regulation will be within its range and the total harmonic distortion will be within its spec. Distortion is worse than tap switchers, and depends on the power factor and load as well as frequency.

Overload Recovery

Overload Recovery refers to the current limiting condition in most ferros. When the output current exceeds the overload protection spec the device will automatically shut down the output voltage. After a certain amount of time the unit will bring the voltage back up and try again. This is listed in the Overload Recovery spec.

Audible Noise

Most ferros make a lot of (audible) noise. Ratings up to 70 dB are common. Noise levels are measured within five feet of the unit; this distance is stated in the spec. Thus, ferros must be sound proofed, or their effects on people within hearing range will be detrimental.

When suggesting a ferro for a customer's consideration, still more things must be considered. Technical operation and environmental concerns, such as weight and air conditioning, must be included in the decision.

Some ferros, like tap switchers, are available with options. Most offer none, requiring only input and output wiring. Others are part of power 'management and distribution' centers. Others are offered in a package with computer quality air conditioning.

ELECTRICAL CODES

APPENDIX

D

This appendix contains selections from national electrical codes, which in the opinion of experienced HP Site Prep CEs are relevant to HP Computer sites. This material WILL NOT make you an expert on electrical codes. In any case of disagreement between this material and a local electrical inspector's interpretation of his code book, remember that the local rule takes precedence.

This appendix presently contains material from the National Electrical Code® (NEC)®. For subsequent editions of this book, the Product Support Division (PRSD) invites contributions from CEs outside the United States. Before submitting anything, however, you must accept the following responsibilities:

(a) -- Any contribution must include your name, telephone number, Comsys and/or HPDESK number, and mailing address, so any other site prep CE in your country can contact you with any questions he or she may have.

(b) -- You will submit any corrections called to your attention for the next edition or update of the handbook. Likewise, you will keep abreast of changes in your codes and submit them when they occur.

(c) -- If you leave site prep duties, you will see to it that someone else picks up your responsibility for keeping the material up to date.

(d) -- Be aware that if you quote from your code, you should ask the source if you need written permission to do so.

Submit contributions via HPDESK or on typed, double-spaced pages, or a computer-generated printout. If you can, please supply a TDP-formatted restore tape with the printout. (If you do send a tape, and you entered the material in any editor other than TDP -- HPSLATE or HPWORD, for instance -- please do NOT justify the margins. Leave the edges ragged and let us justify them in TDP.) Handwritten articles cannot be accepted.

Some countries do not have a nationwide code; thus your statutes or regulations apply only in certain districts, provinces, or territories. In any case, be specific about the exact geographical area where your material applies. Submit material to:

Electrical Codes

Editor, HP CEO Site Prep Handbook
Technical Marketing Department
Product Support Division
Hewlett-Packard
19310 Pruneridge Ave.
Cupertino, CA. 95014
U.S.A.

NATIONAL ELECTRICAL CODE® SELECTIONS

The National Electrical Code® (NEC®) sets guidelines for the United States, and is used in other countries as well. If you want a copy of the Code, write for prices to: National Fire Protection Association (NFPA), Batterymarch Park, Quincy, MA., 02269, USA.

NOTE

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Definitions

Article 100 defines commonly used terms as follows:

Ground -- A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Grounded -- Connected to earth or to some conducting body that serves in place of the earth.

Grounded Conductor -- A system or circuit conductor that is intentionally grounded.

Grounding Conductor -- A conductor used to connect equipment or the grounded circuits of a wiring system to a grounding electrode or electrodes.

Grounding Conductor, Equipment -- The conductor used to connect the non-current-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately-derived system.

Grounding Electrode Conductor -- The conductor used to connect the grounding electrode to the equipment grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately-derived system.

Raceway -- An enclosed channel designed expressly for holding wires, cables, or busbars. A Fine Print Note (FPN) reads, Raceways may be of metal or insulating material, and the term includes rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible metal conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

Service Conductor -- The supply conductors that extend from the street main or from transformers to the service equipment of the premises supplied.

Articles and Sections

NOTE

In the following material, the code appears in regular typeface. *Explanations provided by the staff of the NFPA are in italics.* The distinction is that the code itself has been adopted through an official standards-making system by the entire NFPA membership. The *staff commentary, in italics*, has not necessarily been adopted by the entire membership of the Association. The material in italics is reprinted with permission from the National Electrical Code® Handbook, Copyright© 1983, National Fire Protection Association, Quincy, Mass., 02269.

Section 250-5 is titled Alternating-Current Circuits and Systems to be Grounded. Paragraph (b) is titled Alternating-Current Systems of 50 Volts to 1000 Volts. It reads: AC systems of 50 volts to 1000 volts supplying premises wiring and premises wiring systems shall be grounded under any of the following conditions:

Electrical Codes

(1) - Where the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts.

(2) - Where the system is nominally rated 480Y/277-volt, three-phase, four-wire in which the neutral is used as a circuit conductor.

(3) - Where the system is nominally rated 240/120-volt, three-phase, four-wire in which the midpoint of one phase is used as a circuit conductor.

NOTE

Other parts of Section 250-5 deal with AC systems of less than 50 volts or more than 1000 volts, and with rarely-used grounding exceptions involving melting furnaces, tempering, etc. In this case, the NFPA gave permission to quote Paragraph (b) without quoting the entire section.

Section 250-25, Conductor to be Grounded -- Alternating-Current Systems, reads: For AC premises wiring systems, the conductor to be grounded shall be as specified in (1) through (5) below.

(1) - Single-phase, two-wire: one conductor.

(2) - Single-phase, three-wire: the neutral conductor.

(3) - Multiphase systems having one wire common to all phases: the common conductor.

(4) - Multiphase systems requiring one grounded phase: one phase conductor.

(5) - Multiphase systems in which one phase is used as in (2) above: the neutral conductor. Grounded conductors shall be identified by the means specified in Article 200. (Article 200 specifies colors for various wires, receptacles, etc.)

Section 250-32, Service Raceways and Enclosures, reads: Metal enclosures for service conductors and equipment shall be grounded.

Section 250-33, Other Conductor Enclosures, reads: Metal enclosures for other than service conductors shall be grounded.

The NFPA staff has this comment about Section 250-33: This section requires bonding, grounding, and electrical continuity of metal raceways and thus requires

connectors, couplings, or other fittings that provide bonding and grounding continuity between the fitting and the raceway metal (such as would be required for liquidtight flexible metal conduit). Metal enclosures are required to be grounded, so that any fault between an ungrounded (hot) conductor and a metal enclosure will not allow the enclosure to become energized and remain so and thus present a shock hazard to persons.

The text of Section 250-33 then continues:

Exception No. 1: Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable, if in runs of less than 25 feet (7.62 m), if free from probable contact with ground, grounded metal, metal lath, or other conductive material, and if guarded against contact by persons shall not be required to be grounded.

Exception No. 2: Metal enclosures used to protect cable assemblies from physical damage shall not be required to be grounded.

Section 250-54, Common Grounding Electrode, reads: Where an AC system is connected to a grounding electrode in or at a building as specified in Sections 250-23 and 250-24, the same electrode shall be used to ground conductor enclosures and equipment in or on that building. Two or more electrodes that are effectively bonded together shall be considered as a single electrode in this sense.

NOTE

Section 250-54 above refers the reader to Sections 250-23 and 250-24. The reader may then wonder, in this and other cases, why such "referenced" Sections are not included here. The reason is that when you turn to Sections 250-23 and 250-24, you find that they, in turn, reference other sections, and those sections, in turn, reference still other sections, and so on, and so on, indefinitely. In most cases, the NFPA does not permit partial quotations. When any part of a section is used, the NFPA usually insists that the entire section, including all Exceptions and Fine Print Notes, be included. The editor of this book, who had been assured by experienced HP CEs that Section 250-54 was important, thus had to pick one of the following choices: (a)--Print Section 250-54 as is, and hope the reader obtains a copy of the Code and looks up Sections 250-23 and -24 for himself; or (b)--Include Sections 250-23 and -24, AND any sections THEY reference, AND any sections referenced by THOSE sections, and so on indefinitely; or (c)--omit Section 250-54 entirely. He chose course (a).

Section 250-74, Connecting Receptacle Grounding Terminal to Box, reads: An equipment bonding jumper shall be used to connect the grounding terminal of a grounding-type receptacle to a grounded box.

Exception No. 1: Where the box is surface mounted, direct metal-to-metal contact between the device yoke and the box shall be permitted to ground the receptacle to the box. This Exception shall not apply to cover-mounted receptacles unless the box and cover combination are listed as providing satisfactory ground continuity between the box and the receptacle.

Exception No. 2: Contact devices or yokes designed and listed for the purpose shall be permitted in conjunction with the supporting screws to establish the grounding circuit between the device yoke and flush-type boxes.

Exception No. 3: Floor boxes designed for and listed as providing satisfactory ground continuity between the box and the device.

Exception No. 4: Where required for the reduction of electrical noise (electromagnetic interference) on the grounding circuit, a receptacle in which the grounding terminal is purposely insulated from the receptacle mounting means shall be permitted. The receptacle grounding terminal shall be grounded by an insulated equipment grounding conductor run with the circuit conductors. This grounding conductor shall be permitted to pass through one or more panelboards without connection to the panelboard grounding terminal as permitted in Section 384-27, Exception No. 1, so as to terminate directly at an equipment grounding conductor terminal of the applicable derived system or service.

(Fine Print Note): Use of an isolated equipment grounding conductor does not relieve the requirement for grounding the raceway system and outlet box.

The NFPA staff has this comment about the preceding Fine Print Note: This Fine Print Note, new in the 1984 NEC, was added as a reminder that metallic raceways and boxes are still required to be grounded in the usual manner. This could require a separate grounding conductor, for example, to ground a metal box in a nonmetallic raceway system, or to ground flexible metal conduit. Use of an existing equipment grounding conductor as the isolated receptacle grounding conductor when replacing an ordinary grounding-type receptacle with an isolated ground receptacle could effectively defeat or seriously compromise the required box or raceway ground.

Section 300-10, Electrical Continuity of Metal Raceways and Enclosures, reads: Metal raceways, cable armor, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor, and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity. Raceways and cable assemblies shall be mechanically

secured to boxes, fittings, cabinets, and other enclosures, except as provided for nonmetallic boxes in Section 370-7(c).

The NFPA staff has this comment about Section 300-10: Metal raceways, metal armor or sheaths of cable, metal outlet or junction boxes, and fittings, such as connectors, couplings, locknuts, bushings, etc., must form an effective low impedance path to ground to conduct safely any fault current and facilitate the operation of overcurrent devices protecting the enclosed circuit conductors.

Article 645 deals with Data Processing Systems. *The NFPA staff comments: Article 645 includes only equipment and wiring in the data processing room. A data processing room is usually an enclosed area, with one or more means of entry, that contains data processing equipment.*

Section 645-3, Disconnecting Means, reads: A disconnected means shall be provided to disconnect the power to all electronic equipment in the data processing room. This disconnecting means shall be controlled from locations readily accessible to the operator at the principal exit doors. There shall also be a similar disconnecting means to disconnect the air conditioning system serving this area.

Section 645-4, Grounding, reads: All exposed noncurrent-carrying metal parts of a data processing system shall be grounded in accordance with Article 250.

CONSULTANTS AND VENDORS

APPENDIX

E

This appendix contains lists (or descriptions) of (a) - consultants who provide analytical services for customers; and (b) - vendors who sell equipment customers may need. When giving a customer any such list, make it clear you are offering it only to help her make a choice. She is not obligated to choose from the list, nor should she assume no other vendors or consultants are available. Also mention that HP has no involvement in the financial arrangements between the customer and the vendor or consultant.

As always, be careful about using the word "recommended" in connection with consultants or vendors. Words like "suggested" are safer, as they pose no danger of inadvertently implying a connection with the customer's CSSA. Refer to Section 1 of this book if you need to refresh your memory about the word recommended. The safest course is to avoid any adjective when talking about consultants or vendors, and instead say it exactly as it appears below. For example, in the case of EMI consultants, say "Here is a list of consultants who have told HP they meet the attached criteria".

EMI CONSULTANTS

The following EMI consultants have informed Product Support Division (PRSD) they meet a minimum set of criteria. The criteria are listed following the consultants.

COMSEARCH, INC., 11503 Sunrise Valley Drive, Reston, Virginia, 22091, USA. Phone (703) 620-6300. Services available worldwide.

CONTROL DATA, 4201 Lexington Avenue North, Arden Hills, Minnesota, 55112, USA. Phone (612) 482-2829. Available in United States only.

NORTHWEST ENGINEERING SERVICE, P.O. Box 1888, Poulsbo, Washington, 98370, USA. Phone (206) 779-7069. United States only.

R & B ENTERPRISES, 20 Clipper Road, Conshohocken, Pennsylvania, 19428, USA. Phone (215) 825-1960. Available worldwide.

SACHS/FREEMAN ASSOCIATES, INC., 14300 Gallant Fox Lane, Suite 214, Bowie, Maryland, 20715, USA. Phone (301) 262-4400. OR: 2970 Maria Avenue, Suite 107, Northbrook, Illinois, 60062, USA. Phone (312) 564-1070. Available worldwide.

SANDERS ASSOCIATES, INC., 95 Canal Street, Nashua, New Hampshire, 03061, USA. Phone (603) 885-3602. Available worldwide.

DON WHITE CONSULTANTS, INC., State Route 625, P.O. Box D, Gainsville, Virginia, 22065, USA. Phone (703) 347-0030. Available worldwide.

Consultants and Vendors

The criteria for inclusion in the list were:

- (a) -- Consultant must not require the customer to provide any equipment or material.
- (b) -- Staff must be large enough to ensure reasonable availability, i.e., at least three full-time consultants for USA only, or five worldwide.
- (c) -- Must have extensive EMI experience, including its affects on data processing equipment.
- (d) -- Must have adequate equipment for measurement and troubleshooting.
- (e) -- Must provide a findings report for each site, including results and measured data.
- (f) -- Should not have an affiliation with only one manufacturer for shielding, filtering, etc., but rather a working knowledge of what is available, in order to suggest the most economical solution to customer's site problem.
- (g) -- Must be price-competitive, i.e., \$60 - \$100 per hour with no minimum number of hours.

LINE TREATMENT DEVICE VENDORS

The Support Engineering Group, Technical Marketing Department, at PRSD is continually evaluating line treatment device vendors and updating lists of those who meet certain minimum specifications. Because of the frequency of changes in the lists, they are not included here. However, each time a list is updated, it is distributed to District CE Managers (DCEMs), Country CE Managers (CCEMs), and Technical Support Managers (TSMs) world-wide. Contact them for the current lists. If you need a copy of the specs used in the selection process (it is lengthy), contact PRSD.

Line Treatment Device Customer Letter

The following letter may be used on your office's letterhead when suggesting that a customer purchase a line treatment device from a vendor who has met PRSD's specifications. Please DO NOT modify the letter; it has been approved by Corporate to ensure no implied HP liability. Using it as-is will guarantee consistent worldwide presentation.

Dear _____:

As we have recently discussed, you may require a power line conditioner. Hewlett-Packard does not supply a power line conditioner which is suitable for your system. I will work with you to determine the types and sizes of power conditioners which will best fit your needs. To assist you in locating a line conditioner I am supplying, at your request, the attached list of vendors and a worksheet for defining your power line conditioning needs.

Hewlett-Packard is providing this list for the convenience of its customers and does not intend to imply that these are either the best or the only alternatives for purchase of line conditioners. Hewlett-Packard cannot be a party to any negotiations or contracts you may undertake with non-HP suppliers; neither can we warrant or be otherwise responsible for their efforts. Similarly, since any product or service by others is not an HP offering, HP does not assume responsibility for results obtained, breach of agreement, failure of non-HP persons to perform, or any resulting damages.

I hope you find the attached information beneficial. If you have any further questions regarding line conditioners, please contact me at (phone number).

Sincerely,

(Signature)

Notice that the letter does not contain the word "recommended", nor "approved", nor any other modifier. The letter states that we are offering the customer a list of vendors. Period.

FIELD CONTRIBUTIONS

APPENDIX

F

This appendix is for contributions from site prep CEs. Articles on any site prep subject except electrical codes are welcome. (Electrical codes have Appendix D to themselves.) If you have any questions about or wish to debate anything in this appendix, DIRECT YOUR COMMENTS TO THE AUTHOR OF THE ARTICLE, whose name and location are listed at the start of the article.

Before submitting an article for this appendix, read the first page of Appendix D and agree to the responsibilities listed there (ensuring that someone keeps the material up to date if you leave site prep duties, etc.). Send articles to the address listed in Appendix D. Include your opinions if you like, but make a clear distinction between your opinions and the facts. Spell them out: where relevant, write "In my opinion" or "I believe".

Do not submit short, "newsy" items, nor those that need to be published quickly. Support Update is the appropriate vehicle for those items. PRSD reserves the right to edit all submissions for consistency with the policies and procedures described in this book. Additionally, your article may be sent to experienced site prep engineers in other regions of the world to check for possible differences among regions. Any significant change will be returned to you for approval before publication. Who decides what a significant change is? You guessed it.

If you can submit your article on tape, in TDP, we will appreciate it. If you send a tape, and you use any editor other than TDP, please do NOT justify the margins; leave them ragged. Handwritten items will not be accepted.

ISOLATED GROUND RECEPTACLES

This article is by Mike Abramson of the Rockville Training Center. Mike can be contacted at: HP Rockville Training Center, 4 Choke Cherry Road, Rockville, MD., 20850, USA. Telephone: Telnet, 258-5998; non-Telnet, 301-258-2000, Ext. 5998. Comsys No. 4400.

As you are probably aware, the customer's computer benefits when power is supplied via isolated ground (wiring and) receptacles. These devices keep the green ground screw separate from the mounting frame which would normally be grounded when attached to the metal outlet box. The green ground wire which comes from the ground to neutral bond connects to the isolated ground screw to properly connect the chassis of HP equipment to the zero volt reference. This satisfies the simultaneous objectives of a "clean" ground and an alternate path for any fault current.

Field Contributions

Although several manufacturers make 120V, 20A receptacles, they do it differently. I've examined several units available in my area, and although they all follow the "letter" of the law, some of them, in my opinion, don't follow its "spirit." I've listed the receptacles alphabetically here. All except the Pass and Seymour carry part number IG-5362 or 5362-IG.

Bryant

The Bryant unit has an orange face and completely isolates the ground screw from the mounting frame with an internal piece of plastic. I believe this is a high-quality unit.

Circle F

The Circle F unit has an orange triangle symbol on an ivory face. To isolate the ground screw, thin, orange plastic isolating tabs are attached to the mounting ears. This unit needs a plastic face plate.

Hubbell

Like Bryant, the Hubbell unit has an orange face plate. By using an internal plastic isolating strip, it allows a metal face plate to cover the outlet. In my judgment, this is another high-quality receptacle.

Leviton

Leviton uses black plastic insulators attached to the mounting frame ears to isolate the ground screw. It has an orange face with a green dot, and needs a plastic face plate.

Pass and Seymour

The Pass and Seymour, part no. IG 6300, differs from the other units in that half the mounting frame is isolated and half is not. The outlet separates the ground screw, but doesn't do it simply. If your customer wants to use this receptacle, I strongly suggest that he use a plastic face plate to ensure that the "clean" ground doesn't short to the "dirty" ground.

Slater

Like the Circle F unit, the Slater has an ivory face with an orange triangle. However, it does not need a plastic cover plate because it has a full-length plastic isolating strip.

General Observations

All the units are boxed and include instructions noting the special nature of the outlet. Some explanations were more detailed than others. In some cases wiring diagrams were included.

In my opinion, these were the manufacturers' higher quality units. The quality was attained by better construction, better plastic, and higher quality hardware. All units could be wired from the back or side.

Because of low demand for these devices, they are relatively expensive. These units cost about \$10 each. All were available at electrical supply stores, but of course not all brands were available at all stores.

Suggestions

Based on my findings, I suggest that customers buy outlets that have orange faces and do not need plastic face plates. If the customer wants to add an extra margin of safety, however, he may want to install plastic face plates on the units anyway. If a line noise problem should develop later, this "double protection" could save hours of troubleshooting time.

Advise the customer to mount the outlets with the ground pin up.

If an existing site develops a ground noise problem, I suggest you confirm that any isolated receptacles that need plastic face plates, actually have them.

ELECTRICAL HPDRAWINGS AVAILABLE

J. P. Friedman of Rolling Meadows, US Midwest SR, has developed a package of electrical diagrams using HPDraw. These could be helpful if you prepare drawings for your customer. See Figures F-1 and F-2 for examples of the drawings.

J. P. will make the drawings available to any site prep CE. Contact him at HP Midwest SR, 5201 Tollview Drive, Rolling Meadows, Illinois, 60008, USA. Comsys 2601. Telephone: Telnet, 255-2475; non-Telnet, 312-255-9800, Ext' 2475.

J. P. says you need the following in order to take advantage of the drawings:

(a) - Any HP 3000 System terminal with graphics capability. The terminal must be connected to a host system with HPDraw on it, at a baud rate no faster than 4800.

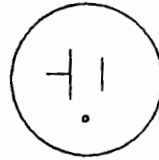
(b) - A plotter or LASER printer.

Field Contributions

(c) - A working knowledge of HPDraw (refer to manual no. 32108-90001).

Several files must be restored into your logon account in order to access the HPDraw files. By contacting J. P., he can arrange a method of transferring the files, and a set of operating instructions, to you.

N520R



NEMA 5-20R
120VAC, 20A SINGLE PHASE
HUBBELL IG5362
BRYANT 5362IG

P64



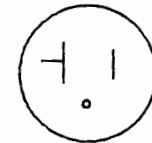
NEMA L21-30R
120/208VAC, 30A, THREE PHASE
HUBBELL IG2810
PASS SEYMOUR IG2130R

PLUG1

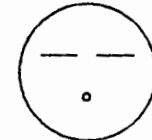


NEMA L14-20R
120/240VAC, 20A, SINGLE PHASE
BRYANT 71420IG
HUBBELL IG2410

PLUGS



NEMA 5-20R
120VAC, 20A SINGLE PHASE
HUBBELL IG5362
BRYANT 5362IG



NEMA 6-30R
208/240VAC, 30A
SINGLE PHASE
PASS SEYMOUR IG5930
BRYANT 9630IGFR

Figure F-1. Example HPDrawing Available from J. P. Friedman

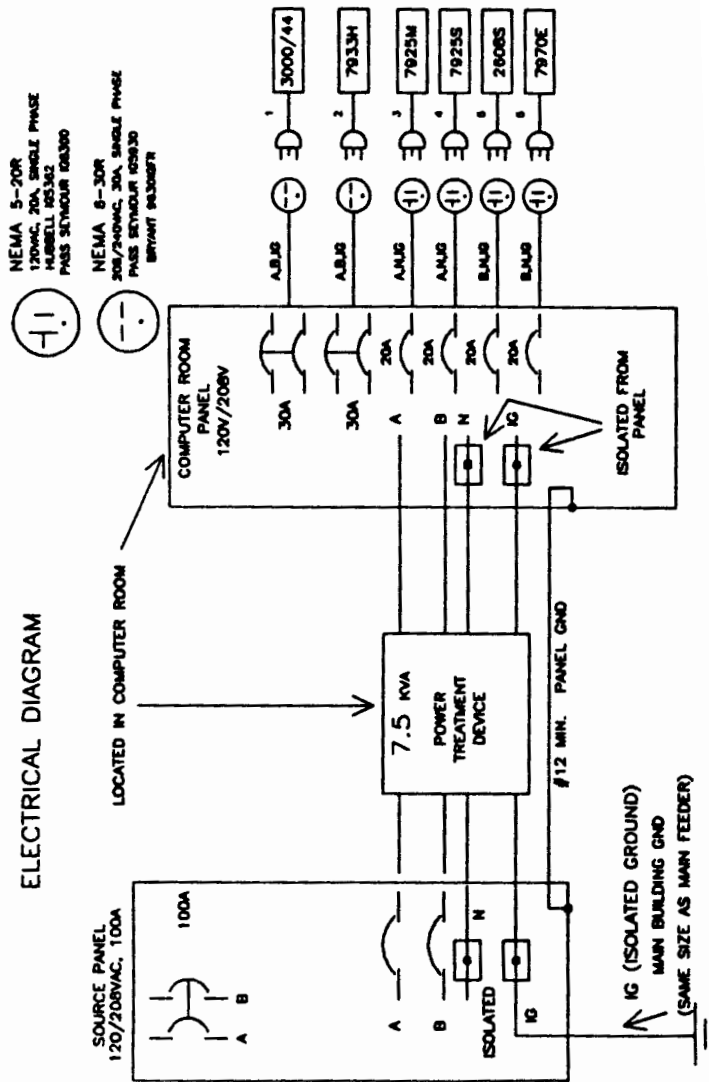


Figure F-2. Example HPDdrawing Available from J. P. Friedman

SITE PREP ARITHMETIC

APPENDIX

G

This appendix is an at-a-glance source of useful site prep arithmetic. Some of it appears with explanations and definitions elsewhere in the text of this book. Some of it, e.g. Handy Metric Conversions, is included although it does not appear elsewhere in the book. No explanations or definitions are provided in this appendix.

POWER AND HEAT FORMULAS

FINDING VA IN A THREE-PHASE SYSTEM

Example: Assume a three-phase system with voltage = 208;
current = 14A/phase.

- 1 -- Divide nominal voltage by 1.73.
$$208 / 1.73 = 120V.$$
- 2 -- Add phase currents.
$$14 + 14 + 14 = 42A.$$
- 3 -- Multiply V by A.
$$120V * 42A = 5040VA.$$

FINDING AMPS PER PHASE IN A 208V SPLIT-PHASE SYSTEM

Example: Assume a 208V split-phase system with a division-specified 9.3A/phase.

- 1 -- Multiply specified current per phase by 1.7.
$$9.3 * 1.7 = 15.8$$
- 2 -- Divide by two.
$$15.8 / 2 = 7.9A$$

Therefore, plan for 7.9A per phase in each of two phases when doing line load-balancing.

Site Prep Arithmetic

FINDING BTU/HR using previous THREE-PHASE example

1 -- Find Watts. Watts = VA times Power Factor.
If Power Factor is unknown, assume .85.

$$5040\text{VA} * .85 = 4284 \text{ Watts.}$$

2 -- BTU/Hr = Watts times 3.414.

$$4284\text{W} * 3.414 = 14626 \text{ BTU/Hr.}$$

FINDING KILO-CALORIES

$$\text{KCal} = \text{BTU} * .252.$$

$$14626 * .252 = 3686 \text{ KCal.}$$

HANDY METRIC CONVERSIONS

DISTANCE

$$\text{Feet} = \text{Metres times } 3.281$$

$$\text{Metres} = \text{Feet times } .3048$$

$$\text{Inches} = \text{Centimetres times } .3937$$

$$\text{Centimetres} = \text{Inches times } 2.54$$

WEIGHT

$$\text{Pounds} = \text{Kilograms times } 2.205$$

$$\text{Kilograms} = \text{Pounds times } .4535$$

TEMPERATURE

$$\text{Degrees F} = (\text{Degrees C} + 17.8) \text{ times } 1.8$$

$$\text{Degrees C} = (\text{Degrees F} - 32) \text{ times } .556$$

PRODUCT SPECIFICATIONS

APPENDIX

Z

This appendix contains electrical, environmental, and physical specifications for HP computer products. The specs for each product were provided by the division that manufactured it and/or is responsible for supporting it. The supporting division is identified at the top of the first page of specs for each product. DIRECT ANY QUESTION ABOUT A PRODUCT'S SPECS TO THE SUPPORTING DIVISION.

GENERAL COMMENTS

Unless labeled otherwise, all values on the spec sheets are maximums. E.g., if a product lists one volt per metre under "EMI Susceptibility", one volt is the maximum allowable. Above one volt, the site does not meet that recommended spec for that product.

If nothing appears under a spec, the supporting division does not have the data available, or has not tested for it, or simply does not release that spec for that product. Where a spec is "Not Applicable" to a product, it is labeled as such. E.g., three phase specs, as "Line to Line Power Imbalance", do not apply to one phase products.

CONTENTS

HP Computer products are grouped into the following categories in this appendix: 1000 Computers, 3000 Computers, 9000 Computers, Disc Drives, Tape Drives, Line Printers, and Board Test Systems. Within each category, products are ordered by their product number, which appears at the upper right on each spec sheet.

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Z-1



Product: HP 1000 Model 60, E-Series Computer, CPU Only No. 2178C

Responsible Support Division: Data Systems Division (DSD), Cupertino, CA.

Page 1. ELECTRICAL SPECIFICATIONS: POWER AND HEAT

INPUT VOLTAGE/FREQUENCY

Nominal	115V / 60Hz	220V
Range	88-132V / 48-66Hz	167-264V

CURRENT, in AMPERES

Typical Steady-State	9.9
Maximum Steady-State	
Surge/Duration in Hz	23.3A/28ms

POWER USE, in VOLT-AMPS

Typical	1118
Maximum	

POWER USE, in WATTS

Typical	980
Maximum	

HEAT GENERATION

Typical: BTUs/h	3346
kcal/h	843
Maximum: BTUs/h	
kcal/h	

Page 2. OTHER ELECTRICAL SPECIFICATIONS

POWER LINE SUSCEPTIBILITY TO CONDUCTED TRANSIENTS				
Voltage Transients		Frequency Transients		Spike Transients
% of Nominal	Duration, ms	% of Nominal	Duration, ms	Amplitude, in volts
				Rise Time, microseconds
				Duration, microseconds

LINE-TO-LINE POWER IMBALANCE (%)
(Not Applicable)

NEUTRAL-GROUND VOLTAGE		HARMONIC CONTENT (VOLTAGE DISTORTION) %
NOMINAL	WORST CASE	5

POWER FAIL SENSITIVITY (WORST CASE VOLTAGE)		CIRCUIT BREAKER SUGGESTED	
TIME (ms)	CYCLES	SIZE	TYPE

Page 3. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE, Degrees				
OPERATING			NON-OPERATING	
Recommended	Minimum/Maximum			
C:	C: 10 to 40		C: -40 to 65	
F:	F: 50 to 104		F: -40 to 149	
RELATIVE HUMIDITY, Non-Condensing, %			ALTITUDE	
OPERATING			OPERATING	NON-OPERATING
Recommended	Min/Max	NON-OPERATING	m: 3,100	m: 7,600
	20-80		ft:10,000	ft:25,000
RADIATED EMI SUSCEPTIBILITY (VOLTS/METRE @ 14 kHz - 1 GHz)			ESD SUSCEPTIBILITY (VOLTS)	
			15k	
AIRBORNE CONTAMINATION				
ARTICULATES (micrograms/cubic metre)			COPPER CORROSION (Angstroms/Year)	

Page 4. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: 115.6	cm: 76.4	cm: 187.1	kg: 190.5
in: 45.5	in: 31	in: 74	lb: 420

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: 161.3	cm: 63.5	cm: 81.3	kg: 164.1
in: 63.4	in: 25	in: 32	lb: 361

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
cm:				
in:				

POWER CABLES (LENGTH in Centimetres and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female
cm: 295		
in: 116		

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	SHIPPED LENGTH	INTERNAL HP-IB CABLE LENGTH
			4 metres
			13.1 feet

Product: HP 1000 Model 65 F-Series Computer, CPU and Floating Point Processor (FPP).
No. 2179C

Responsible Support Division: Data Systems Division (DSD), Cupertino, CA.

Page 1. ELECTRICAL SPECIFICATIONS: POWER AND HEAT

INPUT VOLTAGE/FREQUENCY	CPU	FPP
Nominal	110V / 60Hz	120V / 60Hz
Range	88-132V / 48-66Hz	108-132V / 48-66Hz
CURRENT, in AMPERES		
Typical Steady-State	9.9	2.5
Maximum Steady-State		
Surge/Duration in Hz	23A/28ms	5.3A/16ms
POWER USE, in <u>VOLT-AMPS</u>		
Typical		
Maximum		
POWER USE, in <u>WATTS</u>		
Typical	490	130
Maximum		
HEAT GENERATION		
Typical: BTUs/h	1673	444
kcal/h	422	112
Maximum: BTUs/h		

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Z-1000-5

Page 2. OTHER ELECTRICAL SPECIFICATIONS

POWER LINE SUSCEPTIBILITY TO CONDUCTED TRANSIENTS

Voltage Transients		Frequency Transients		Spike Transients
% of Nominal	Duration, ms	% of Nominal	Duration, ms	Amplitude, in volts
				Rise Time, microseconds
				Duration, microseconds

LINE-TO-LINE POWER IMBALANCE (%)

(Not Applicable)

NEUTRAL-GROUND VOLTAGE		HARMONIC CONTENT (VOLTAGE DISTORTION, %)
NOMINAL	WORST CASE	
		5

POWER FAIL SENSITIVITY (WORST CASE VOLTAGE)		CIRCUIT BREAKER SUGGESTED	
TIME (ms)	CYCLES	SIZE	TYPE
10.9	.5	20A	

Page 3. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE, Degrees

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:	C: 10 to 40	C: -40 to 65
F:	F: 50 to 104	F: -40 to 149

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
	20-80	

ALTITUDE

OPERATING	NON-OPERATING
m: 3,100	m: 7,600
ft: 10,000	ft: 25,000

RADIATED EMI SUSCEPTIBILITY
(VOLTS/METRE @ 14 kHz - 1 GHz)

ESD SUSCEPTIBILITY

15k

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cubic metre)	COPPER CORROSION (Angstroms/Year)
---------------------------------------	-----------------------------------

Page 4. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: 115.6	cm: 78.4	cm: 187.1	kg: 190.5
in: 45.5	in: 31	in: 74	lb: 420

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: 161.3	cm: 63.5	cm: 81.3	kg: 184.5
in: 63.4	in: 25	in: 32	lb: 406

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
-----	-----	-----	-----	-----
cm:	91.4	91.4	91.4	91.4
in:	36	36	36	36

POWER CABLES (LENGTH in Centimetres and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE	
		Male	Female
cm: 295			
in: 116			

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	SHIPPED LENGTH	INTERNAL HP-IB CABLE LENGTH
			4 metres 13.1 feet

Product: HP 1000 Model 26 Computer System. CPU Only No. 2196C/D

Responsible Support Division: Data Systems Division (DSD), Cupertino, CA.

Page 1. ELECTRICAL SPECIFICATIONS: POWER AND HEAT

INPUT VOLTAGE/FREQUENCY

Nominal	115V / 60Hz	230V
Range	86-138V / 48-66Hz	178-276V

CURRENT, in AMPERES

Typical Steady-State

Maximum Steady-State*	10.8	4
Surge/Duration in Hz	49.5A/28ms	

POWER USE, in VOLT-AMPS

Typical

Maximum*	928	1112
----------	-----	------

POWER USE, in WATTS

Typical

Maximum*	740	735
----------	-----	-----

HEAT GENERATION

Typical: BTUs/h

	kcal/h	
Maximum: BTUs/h	2525	2508
	kcal/h	637
		632

Page 2. OTHER ELECTRICAL SPECIFICATIONS

POWER LINE SUSCEPTIBILITY TO CONDUCTED TRANSIENTS

Voltage Transients		Frequency Transients		Spike Transients
% of Nominal	Duration, ms	% of Nominal	Duration, ms	Amplitude, in volts
				Rise Time, microseconds
				Duration, microseconds

LINE-TO-LINE POWER IMBALANCE (%)

(Not Applicable)

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

HARMONIC CONTENT (VOLTAGE DISTORTION) %

5

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (ms)	CYCLES
10.9	.5

CIRCUIT BREAKER SUGGESTED

SIZE	TYPE
20A	

* Conditions Under Which Maximum Steady-State Values Were Measured:

The CPUs were tested with a 440W DC load in the backplane.

115V System: Maximum steady-state current of 10.8A was measured at 86V, 48Hz. The 86V was used to calculate the Maximum Volt-Amp value of 928 (86V times 10.8A = 928). Actual maximum Watts (740), however, were measured at 138V, 48Hz.

230V System: Maximum current, Volt-Amps, and Watts were all measured/calculated at 276V, 48Hz.

Page 3. ENVIRONMENTAL SPECIFICATIONS

 AMBIENT TEMPERATURE, Degrees

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:	C: 0 to 40	C: -40 to 75
F:	F: 32 to 104	F: -40 to 167

 RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
	5-95	

 ALTITUDE

OPERATING	NON-OPERATING
m: 4,600	m: 15,300
ft: 15,000	ft: 50,000

RADIATED EMI SUSCEPTIBILITY
 (VOLTS/METRE @ 14 kHz - 1 GHz)

ESD SUSCEPTIBILITY (VOLTS)

15k

 AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cubic metre)	COPPER CORROSION (Angstroms/Year)
---------------------------------------	-----------------------------------

Page 4. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
cm: 185.4	cm: 86.4	cm: 104.1	kg: 195
in: 73	in: 34	in: 41	lb: 430

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
cm: HP2196C: 161.3 HP2196D: 72	cm: 69.9	cm: 81.3	kg: HP2196C: 139.7 HP2196D: 94
in: HP2196C: 63.4 HP2196D: 28.3	in: 27.5	in: 32	lb: HP2196C: 307 HP2196D: 207

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
cm:	91.4	91.4	91.4	91.4
in:	36	36	36	36

POWER CABLES (LENGTH in Centimetres and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female
cm: 182.8		
in: 72		

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	SHIPPED LENGTH	INTERNAL HP-IB CABLE LENGTH
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Responsible Support Division: Data Systems Division (DSD), Cupertino, CA.

Page 1. ELECTRICAL SPECIFICATIONS: POWER AND HEAT

Nominal	115V / 60Hz	230V
Range	86-138V / 48-66Hz	178-276V

Typical Steady-State	
Maximum Steady-State*	10.8 4
Surge/Duration in Hz	49.5A/28ms

Typical		
Maximum*	928	1112

Typical		
Maximum*	740	735

Typical: BTUs/h		
kcal/h		
Maximum: BTUs/h	2525	2508
kcal/h	637	632

Dec 86
Z-1000-13

Page 2. OTHER ELECTRICAL SPECIFICATIONS

POWER LINE SUSCEPTIBILITY TO CONDUCTED TRANSIENTS

Voltage Transients		Frequency Transients		Spike Transients
% of Nominal	Duration, ms	% of Nominal	Duration, ms	Amplitude, in volts
				Rise Time, microseconds
				Duration, microseconds

LINE-TO-LINE POWER IMBALANCE (%)

(Not Applicable)

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

HARMONIC CONTENT (VOLTAGE DISTORTION) %

5

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (ms) CYCLES

10.9 .5

CIRCUIT BREAKER SUGGESTED

SIZE TYPE

20A

* Conditions Under Which Maximum Steady-State Values Were Measured:

The CPUa were tested with a 440 Watt DC load in the backplane.

115V System: Maximum steady-state current of 10.8A was measured at 86V, 48Hz. The 86V was used to calculate the Maximum Volt-Amp value of 928 (86V times 10.8A = 928). Actual maximum Watts (740), however, were measured at 138V, 48Hz.

230V System: Maximum current, Volt-Amps, and Watts were all measured/calculated at 276V, 48Hz.

Dec 86

Z-1000-14

Page 3. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE, Degrees

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:	C: 0 to 40	C: -40 to 75
F:	F: 32 to 104	F: -40 to 167

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
	5-95	

ALTITUDE

OPERATING	NON-OPERATING
m: 4,600	m: 15,300
ft: 15,000	ft: 50,000

RADIATED EMI SUSCEPTIBILITY
(VOLTS/METRE @ 14 kHz - 1 GHz)

ESD SUSCEPTIBILITY (VOLTS)

15k

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cubic metre)

COPPER CORROSION (Angstroms/Year)



Page 4. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
cm: 185.4	cm: 86.4	cm: 104.1	kg: 195
in: 73	in: 34	in: 41	lb: 430

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
cm: HP2197C: 161.3 HP2197D: 72	cm: 69.9	cm: 81.3	kg: HP2197C: 139.7 HP2197D: 94
in: HP2197C: 63.4 HP2197D: 28.3	in: 27.5	in: 32	lb: HP2197C: 307 HP2197D: 207

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
cm:	91.4	91.4	91.4	91.4
in:	36	36	36	36

POWER CABLES (LENGTH in Centimetres and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female
cm: 182.8		
in: 72		

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	SHIPPED LENGTH	INTERNAL HP-IB CABLE LENGTH
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Dec 86

Z-1000-16

Product: HP 1000 Model 29 Computer System, CPU Only No. 2199C/D

Responsible Support Division: Data Systems Division (DSD), Cupertino, CA.

Page 1. ELECTRICAL SPECIFICATIONS: POWER AND HEAT

INPUT VOLTAGE/FREQUENCY

Nominal	115V / 60Hz	230V
Range	86-138V / 48-66Hz	178-276V

CURRENT, in AMPERES

Typical Steady-State

Maximum Steady-State*	10.8	4
Surge/Duration in Hz	49.5A/28ms	

POWER USE, in VOLT-AMPS

Typical

Maximum*	928	1112
----------	-----	------

POWER USE, in WATTS

Typical

Maximum*	740	735
----------	-----	-----

HEAT GENERATION

Typical: BTUs/h

	kcal/h	
Maximum: BTUs/h	2525	2508
	kcal/h	637
		632

Dec 86
Z-1000-17

Page 2. OTHER ELECTRICAL SPECIFICATIONS

POWER LINE SUSCEPTIBILITY TO CONDUCTED TRANSIENTS

Voltage Transients		Frequency Transients		Spike Transients
% of Nominal	Duration, ms	% of Nominal	Duration, ms	Amplitude, in volts
				Rise Time, microseconds
				Duration, microseconds

LINE-TO-LINE POWER IMBALANCE (%)

(Not Applicable)

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

HARMONIC CONTENT (VOLTAGE DISTORTION) %

5

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (ms) CYCLES

10.9 .5

CIRCUIT BREAKER SUGGESTED

SIZE TYPE

20A

* Conditions Under Which Maximum Steady-State Values Were Measured:

The CPUs were tested with a 440 Watt DC load in the backplanes.

115V System: Maximum steady-state current of 10.8A was measured at 86V, 48Hz. The 86V was used to calculate the Maximum Volt-Amp value of 928 (86V times 10.8A = 928). Actual maximum Watts (740), however, were measured at 138V, 48Hz.

230V System: Maximum current, Volt-Amps, and Watts were measured/calculated at 276V, 48Hz.

Dec 86

Z-1000-18

Page 3. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE, Degrees

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:	C: 0 to 40	C: -40 to 75
F:	F: 32 to 104	F: -40 to 167

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
	5-95	

ALTITUDE

OPERATING	NON-OPERATING
m: 4,600	m: 15,300
ft: 15,000	ft: 50,000

RADIATED EMI SUSCEPTIBILITY
(VOLTS/METRE @ 14 kHz - 1 GHz)

ESD SUSCEPTIBILITY (VOLTS)

15k

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cubic metre)	COPPER CORROSION (Angstroms/Year)
---------------------------------------	-----------------------------------

Product: HP 1000 Model 29 Computer System, CPU Only No. 2199C/D

Page 4. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: 185.4	cm: 86.4	cm: 104.1	kg: 195
in: 73	in: 34	in: 41	lb: 430

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: HP2199C: 161.3 HP2199D: 72	cm: 69.9	cm: 81.3	kg: HP2199C: 139.7 HP2199D: 94
in: HP2199C: 63.4 HP2199D: 28.3	in: 27.5	in: 32	lb: HP2199C: 307 HP2199D: 207

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
cm:	91.4	91.4	91.4	91.4
in:	36	36	36	36

POWER CABLES (LENGTH in Centimetres and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female
cm: 182.8		
in: 72		

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	SHIPPED LENGTH	INTERNAL HP-IB CABLE LENGTH
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Product: HP Micro/1000 Computer Systems, Without Discs
Nos: 2486A/87A/89A

Responsible Support Division: Data Systems Division (DSD), Cupertino, CA.

Page 1. ELECTRICAL SPECIFICATIONS: POWER AND HEAT

INPUT VOLTAGE/FREQUENCY

Nominal	115V / 60Hz	230V
Range	86-138V / 48-66Hz	178-276V

CURRENT, in AMPERES

Typical Steady-State

Maximum Steady-State*	7.8
Surge/Duration in Hz	42A/70ms

POWER USE, in VOLT-AMPS

Typical

Maximum*	623
----------	-----

POWER USE, in WATTS

Typical

Maximum*	420
----------	-----

HEAT GENERATION

Typical: BTUs/h

kcal/h	
Maximum: BTUs/h	1434
kcal/h	361

Product: HP Micro/1000 Computer Systems, Without Discs
Nos: 2486A/87A/89A

Page 2. OTHER ELECTRICAL SPECIFICATIONS

POWER LINE SUSCEPTIBILITY TO CONDUCTED TRANSIENTS

Voltage Transients		Frequency Transients		Spike Transients
% of Nominal	Duration, ms	% of Nominal	Duration, ms	Amplitude, in volts
				Rise Time, microseconds
				Duration, microseconds

LINE-TO-LINE POWER IMBALANCE (%)

(Not Applicable)

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

HARMONIC CONTENT (VOLTAGE DISTORTION) %

5

**POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)**

TIME (ms) CYCLES

CIRCUIT BREAKER SUGGESTED

SIZE TYPE

15A

* Conditions Under Which Maximum Steady-State Values Were Measured:

Computer was tested with a 300 Watt DC load in the CPU Backplane.

Product: HP Micro/1000 Computer Systems, Without Discs
Nos: 2486A/87A/89A

Page 3. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE, Degrees

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:	C: 0 to 45	C: -40 to 75
F:	F: 32 to 113	F: -40 to 167

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
	5-95	

ALTITUDE

OPERATING	NON-OPERATING
m: 4,600	m: 15,300
ft: 15,000	ft: 50,000

RADIATED EMI SUSCEPTIBILITY
(VOLTS/METRE @ 14 kHz - 1 GHz)

ESD SUSCEPTIBILITY (VOLTS)

15k

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cubic metre)	COPPER CORROSION (Angstroms/Year)
--	--

Product: HP Micro/1000 Computer System, Without Discs
Nos: 2486A/87A/89A

Page 4. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: 43.2	cm: 71.1	cm: 89	kg: 28.1
in: 17	in: 28	in: 35	lb: 62

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: 17.8	cm: 48.3	cm: 64.8	kg: 18.2
in: 7	in: 19	in: 25.5	lb: 40

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
cm:				
in:				

POWER CABLES (LENGTH in Centimetres and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female
cm: 182.8		
in: 72		

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	SHIPPED LENGTH	INTERNAL HP-IB CABLE LENGTH



Product: HP 3000 Series 64/68A Computer No. 32460A

Responsible Support Division: Computer Systems Division (CSY), Cupertino, CA.

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)						POWER (VOLT-AMPS)
		PHASE A		PHASE B		PHASE C		
Nominal	Range	Steady- State	Surge	Steady- State	Surge	Steady- State	Surge	
208	187-220	24	200	24	200	24	200	8640
380	342-403	13		13		13		8580
415	374-440	12		12		12		8640

Surge Current Duration: _____

OPERATING FREQUENCIES		CIRCUIT BREAKER REQUIRED	
		SIZE	TYPE
50 Hz nominal, range 49-51		208=30A	
60 Hz nominal, range 58.8-61.2		380=20A	
		415=20A	

LINE-CONDUCTED TRANSIENTS (VOLTS)		PHASE ANGLE IMBALANCE(%)	
100ns rise time; 100us duration (50%); 1000 volts peak; OR 1.5us rise time; 10us duration (50%); 1000 volts peak.		5% from 120 degrees	
LINE-TO-LINE POWER IMBALANCE (%)			
18			

NEUTRAL-GROUND VOLTAGE		HARMONIC CONTENT (DISTORTION)(%)
NOMINAL	WORST CASE	5

POWER FAIL SENSITIVITY (WORST CASE VOLTAGE)		POWER FAIL THRESHOLD VOLTAGE	
TIME (MS)	CYCLES	DROP OUT ("Overload")	TURN ON
20	1 at 50 Hz	229	187
		418	342
		457	373

Dec 86
Z-3000-1

Product: HP 3000 Series 64/68A Computer. No. 32460A

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:20-25.5	C:15-29	C:-40 to 75
	--for 48 hrs max	
F:68-78	F:55.4-85	F:-40 to 167

RELATIVE HUMIDITY (%)

OPERATING		NON-OPERATING
Recommended	Min/Max	
40-60	30-80 (48 hrs max)	30-80

ALTITUDE

OPERATING	NON-OPERATING
M:0-4600	M: 0-15300
Ft:0-15,000	Ft:0-50000

**EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)**

one-half

ESD (VOLTS)

<15k

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)	COPPER CORROSION (Angstroms/Yr)
-----------------------------------	---------------------------------

AIR CONDITIONING (HEAT GENERATION)

BTUs/Hr	KCALs/Hr
208V = 25072	6318
380V = 24898	6274
415V = 25072	6318

Dec 86

Z-3000-2

Page 3. PHYSICAL SPECIFICATIONS

SHIPPING DIMENSIONS AND WEIGHT

HEIGHT: Land;Air	WIDTH: Land;Air	DEPTH: Land;Air	WEIGHT
Cm: 129.5;146	Cm: 81.3;77.5	Cm: 105.4;114.3	*
In: 51 ;57.5	In: 32 ;30.5	In: 41.5; 45	
*Weight: LAND: CPU:204Kg, 450Lb; I/O:290Kg, 640Lb; Aux I/O:145Kg, 320Lb.			
AIR : CPU:234Kg, 515Lb; I/O:317Kg, 700Lb; Aux I/O:172Kg, 380Lb.			

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH: 2-bay; 3-bay	DEPTH	WEIGHT: CPU; I/O; Aux I/O
Cm:122	Cm: 176 ; 268	Cm:66	Kg: 195; 281; 136
In: 48	In: 69 ; 105	In:26	Lb: 430; 620; 300

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
Cm:	91	91	91	91
In:	36	36	36	36

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
		1.5M

Product: HP 3000 Series 64/68B Computer No. 32460B

Responsible Support Division: Computer Systems Division, Cupertino, California

Page 1. ELECTRICAL SPECIFICATIONS
(Measured Values, Two-Bay, Fully-Loaded System)

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)						POWER (VOLT-AMPS)
		PHASE A		PHASE B		PHASE C		
Nominal	Range	Steady- State	Surge	Steady- State	Surge	Steady- State	Surge	
208	177-229	11	500	11	500	11	500	3968
380	323-418	6	325	6	325	6	325	3954
415	353-457	5.5	300	5.5	300	5.5	300	3958

Surge Current Duration: _____

OPERATING FREQUENCIES	CIRCUIT BREAKER REQUIRED
50 Hz nominal, range 47.5-52.5	SIZE TYPE
60 Hz nominal, range 57 - 63	208V=30A
	380V=20A
	415V=20A

LINE-CONDUCTED TRANSIENTS (VOLTS)
100ns rise time; 100 us duration (50%); 1000 volts peak; OR 1.5us rise time; 10 us duration (50%); 1000 volts peak.

LINE-TO-LINE POWER IMBALANCE (%)	PHASE ANGLE IMBALANCE(%)
18%	5% from 120 degrees

NEUTRAL-GROUND VOLTAGE	HARMONIC CONTENT (DISTORTION)(%)
NOMINAL WORST CASE	5

POWER FAIL SENSITIVITY (WORST CASE VOLTAGE)		POWER FAIL THRESHOLD VOLTAGE	
TIME (MS)	CYCLES	DROP OUT ("Overload")	TURN ON
20	1 at 50Hz	229	187
		418	342
		457	373

Dec 86
2-3000-4

Page 2. ENVIRONMENTAL SPECIFICATIONS

 AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C: 20-25.5	C: 15-29	C: -40 to 75
	--for 48 hrs max	
F: 68-78	F: 55.4-85	F: -40 to 167

RELATIVE HUMIDITY, Non-Condensing, %

ALTITUDE

OPERATING		NON-OPERATING	OPERATING	NON-OPERATING
Recommended	Min/Max	30-80	M:0-4600	M:0-15,300
	30-80 (48			
	hrs max)			
40-60			Ft:0-15,000	Ft:0-50,000

EMI SUSCEPTIBILITY
 (VOLTS/METRE @ 14kHz - 1GHz)

ESD (VOLTS)

 0.5

 <15k

 AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)

COPPER CORROSION (Angstroms/Yr)

AIR CONDITIONING (HEAT GENERATION)

BTUs/Hr	KCALs/Hr
208V = 12871	3244
380V = 12823	3231
415V = 12837	3235

Product: HP 3000 Series 64/68B Computer No. 32460B

Page 3. PHYSICAL SPECIFICATIONS

SHIPPING DIMENSIONS AND WEIGHT

HEIGHT: Land;Air	WIDTH: Land;Air	DEPTH: Land;Air	WEIGHT
Cm: 129.5;146	Cm: 81.3;77.5	Cm: 105.4;114.3	*
In: 51 ;57.5	In: 32;30.5	In: 41.5;45	
*Weight: LAND: CPU:204Kg, 450Lb; I/O:290Kg, 640Lb; Aux I/O:145Kg, 320Lb.			
AIR : CPU:234Kg, 515Lb; I/O:317Kg, 700Lb; Aux I/O:172Kg, 380Lb.			

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH: 2-bay;3-bay	DEPTH	WEIGHT: CPU; I/O; Aux I/O
Cm: 122	Cm: 176 ;268	Cm: 66	Kg: 195; 281; 136
In: 48	In: 69 ;105	In: 26	Lb: 430; 620; 300

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
Cm:	91	91	91	91
In:	36	36	36	36

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH 1.5 M
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Product: HP 3000 Series 39 Computer

No. 32514

Responsible Support Division: Office Systems Division, Roseville, California

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
120	108-126	8.5	75	1020
220	216-250	4.5	75	990

Surge Current Duration: _____

OPERATING FREQUENCIES

50/60 Hz

CIRCUIT BREAKER REQUIRED

SIZE TYPE

LINE-CONDUCTED TRANSIENTS (VOLTS)

LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

PHASE ANGLE IMBALANCE (%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

HARMONIC CONTENT (DISTORTION) (%)

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (M/SEC) CYCLES

POWER FAIL
THRESHOLD VOLTAGE

DROP OUT TURN ON
("Overload")

Dec 86
Z-3000-7

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C: 20-25	C:	C:
F: 68-78	F:	F:

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
40-60		

ALTITUDE

OPERATING	N
M:	M:
Ft:	Ft:

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)

ESD (VOLTS)

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)	COPPER CORROSION (Angstroms/Yr)
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AIR CONDITIONING (HEAT GENERATION)

BTUs/hr	KCALs/hr
120V = 2960	746
220V = 2875	725

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm:	Cm:	Cm:	Kg:
In:	In:	In:	Lb:

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 101.6	Cm: 61	Cm: 56.9	Kg: 85
In: 40	In: 24	In: 22.4	Lb: 190

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
Cm:				
In:				

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
	32 Max. (Low Speed)	

Product: HP 3000 Series 42 Computer

No. 32542

Responsible Support Division: Office Systems Division, Roseville, California

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
120	108-126	8.5	75	1020
220	216-250	4.5	75	990

Surge Current Duration: _____

OPERATING FREQUENCIES

50/60 Hz

CIRCUIT BREAKER REQUIRED

SIZE TYPE

LINE-CONDUCTED TRANSIENTS (VOLTS)



LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

PHASE ANGLE IMBALANCE(%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

HARMONIC CONTENT (DISTORTION)(%)

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (M/SEC) CYCLES

POWER FAIL
THRESHOLD VOLTAGE

DROP OUT TURN ON
("Overload")

Dec 86

Z-3000-10

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C: 20-25.5	C:	C:
F: 68-78	F:	F:

RELATIVE HUMIDITY, Non-Condensing, %

ALTITUDE

OPERATING		NON-OPERATING	OPERATING	NON-OPERATING
Recommended	Min/Max		M:	M:
40-60			Ft:	Ft:

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)

ESD (VOLTS)

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)	COPPER CORROSION (Angstroms/Yr)
-----------------------------------	---------------------------------

AIR CONDITIONING (HEAT GENERATION)

BTUs/hr	KCALs/hr
120V = 2960	746
220V = 2875	725

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm:	Cm:	Cm:	Kg:
In:	In:	In:	Lb:

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 101.6	Cm: 61	Cm: 56.9	Kg: 85
In: 40	In: 24	In: 22.4	Lb: 190

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
Cm:				
In:				

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
	32 Max (Low Speed)	

Product: HP 3000 Series 48 Computer

No. 32548

Responsible Support Division: Office Systems Division, Roseville, California

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
210	189-223	13.1	150	2751
220	207-233	12.4	150	2728

Surge Current Duration: _____

OPERATING FREQUENCIES

50/60 Hz

CIRCUIT BREAKER REQUIRED

SIZE TYPE

LINE-CONDUCTED TRANSIENTS (VOLTS)

LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

PHASE ANGLE IMBALANCE(%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

HARMONIC CONTENT (DISTORTION)(%)

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (M/SEC) CYCLES

POWER FAIL
THRESHOLD VOLTAGE

DROP OUT TURN ON
("Overload")

Dec 86
Z-3000-13

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C: 20-25.5	C:	C:
F: 68-78	F:	F:

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
40-60		

ALTITUDE

OPERATING	NON-OPERATING
M:	M:
Ft:	Ft:

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)ESD (VOLTS)

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)	COPPER CORROSION (Angstroms/Yr)
-----------------------------------	---------------------------------

AIR CONDITIONING (HEAT GENERATION)

BTUs/hr	KCALs/hr
210V = 7983	2012
220V = 7919	1996

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm:	Cm:	Cm:	Kg:
In:	In:	In:	Lb:

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm:	Cm:	Cm:	Kg:
In:	In:	In:	Lb:

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
Cm:				
In:				

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
	5 GICs Max. 40 Low Speed HP-IB Loads.	



Product Operational Characteristics

Model #: HP 9000 Model 840 SPU

Data Revision Date: October, 1986
ER Div.: Information Technology Group

1.0 PHYSICAL CHARACTERISTICS

	SPU Alone	Packaged for Shipping
Height:	1 metre (39 in.)	1.27 metre (50 in.)
Width:	0.6 metre (23.4 in.)	0.78 metre (30.75 in.)
Depth:	0.8 metre (31.2 in.)	1.02 metre (40.25 in.)
Weight:	162 kg (357 lb)	236 kg (520 lb)
Maximum point floor loading:		_____ kg (_____ lb)
Minimum required service access:	Rear _____ mm (in.)	
	Sides _____ mm (in.)	
	Front _____ mm (in.)	

2.0 ENVIRONMENTAL SPECIFICATIONS

2.1 TEMPERATURE

(degrees F = 1.8 x degrees C + 32)

Nonoperating/storage Temperature Range: -40 - 70 degrees C
Operating Temperature Range: 0 - 55 degrees C
Recommended Optimum Temperature Range: 20 - 30 degrees C
Temperature Shock Immunity - Maximum
rate of change: 0.3 degrees C/minute
Overtemperature shutdown? yes/no _____ What ambient Temp? _____ degrees C

2.2 HUMIDITY

Nonoperating/storage Humidity Maximum: 90 % RH @ 65 degrees C
Operating Humidity Range: 5 - 95 % RH @ 40 degrees C
Recommended Optimum Humidity Range: 40 - 60 % RH
Procedure for recovery from moisture condensation: _____

2.3 ALTITUDE

Nonoperating: 50,000 feet Operating: 15,000 feet
Temperature derating above 7000 feet, if any: -1.1 degree C/1000 feet.

2.4 MECHANICAL VIBRATION

Maximum Acceleration, Operating: 0.21 g's rms. Frequency range: 5-500 Hz

Product Operational Characteristics (cont'd.)

Model #: HP 9000 Model 840 SPU

Data Revision Date: October, 1986

3.0 AC POWER SPECIFICATIONS

Power cord length: 60Hz, 10 ft. 50Hz (power cord not supplied)
Mating receptacle type: 60Hz, L6-20R

3.1 AC LINE VOLTAGE

Nominal Rated Voltages 200, 208, 230, or 240 VAC
Minimum Operating Voltage: Minus 15% of nominal
Maximum Operating Voltage: Plus 15% of nominal
Rated Line Current: 13A rms

Line voltage power-fail threshold level: _____ Vac _____ Vac
Dropout carry-thru time @ Minimum line: _____ ms _____ ms
Maximum harmonic distortion of voltage waveform, or Minimum Peak/rms ratio (1.41 for sine wave): _____

Frequency Range: 50 to 60 Hz, - 5% to + 10% (47.5 to 66 Hz)

Transient Spike Immunity, and Surge Immunity: Tested to IEEE 587, category B

3.2 LINE CURRENT - Maximum and Typical Configurations

Line current is true-rms amps except for peak inrush.

Amps at Maximum Config. (1 bay system), 208V nominal: 7

Amps at Max. Config., minimum voltage (200V - 15% = 170V): 8

Maximum peak inrush at turn-on: 110 A peak
Time to decay to 25% of max. peak: 50 ms

Temporary start-up current (i.e. motors): _____ A rms
Time duration to return to normal: _____ sec
Peak-to-rms ratio of current waveform: _____

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Z-9000-2

Product Operational Characteristics (cont'd.)

Model #: HP 9000 Model 840 SPU Data Revision Date: October, 1986

3.3 HEAT DISSIPATION - Measured with Wattmeter

Heat Dissipation - Maximum Configuration (15 minutes average): 2000 Watts

Heat Dissipation - Typical Configuration (15 minutes average): Watts

Describe "Typical" configuration (sketch?):

Note: BTUs/hr = $3.41 \times \text{Watts}$. kcal/hr = $.860 \times \text{Watts}$

4.0 MAGNETIC FIELD IMMUNITY

Maximum gauss without affecting functionality or jittering/swimming of CRT display more than two scan lines: 20 Gauss

5.0 RADIATED FIELD IMMUNITY

State frequencies and field strengths (less than 10V/metre) causing functional anomalies: 5V/metre @ 10KHz to 1 GHz

6.0 ESD IMMUNITY

Maximum kV (if less than 15kV) with no loss of function: 15 kV

Maximum kV (if less than 25kV) with no component damage: 25 kV

Describe response:

7.0 ACOUSTIC NOISE

Sound power level (LWA): 65 dB(A)

Sound pressure level (LPA) at operator position: dB(A)

8.0 Additional attachments (yes/no): no



Product: Disc/Tape Drive

No. 7911/12/14P

Responsible Support Division: Disc Memory Division, Boise, Idaho

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
120	108-126	8		960

Surge Current Duration: _____

OPERATING FREQUENCIES

50 Hz nominal, 47.5 - 55
60 Hz nominal, 57 - 66

CIRCUIT BREAKER REQUIRED

SIZE TYPE

LINE-CONDUCTED TRANSIENTS (VOLTS)

Oscillatory wave (100 kHz ringing wave): 1.5 kV
Unidirectional wave (one 20us pulse) : 1 kV

LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

PHASE ANGLE IMBALANCE(%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

10V peak-peak

HARMONIC CONTENT (DISTORTION)(%)

5

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (M/SEC) CYCLES

one-half

POWER FAIL
THRESHOLD VOLTAGE

DROP OUT TURN ON
("Overload")

Dec 86
2-DD-1

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:	C: 10 - 40	C: -40 to 60
F:	F: 50 - 104	F: -40 to 140

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING	OPERATING	NON-OPERATING
Recommended	Min/Max			
	20 - 80, with	10 - 90, with	M: -300 to	M: -300 to
	max .015 lb/water	max wet bulb	4600	15000
	per lb/dry air.	temp 26.5C	F: -984 to	F: -984 to
		(80F).	15092	49213

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)-----
3

ESD (VOLTS)

12.5 kV-----
AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)		COPPER CORROSION (Angstroms/Yr)	
Recommended	Marginal	Recommended	Marginal

AIR CONDITIONING (HEAT GENERATION)

BTUs/hr	KCALs/hr
2389	602

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm:	Cm:	Cm:	Kg: 117.1
In:	In:	In:	Lb: 258

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 72	Cm: 35.4	Cm: 71.1	Kg: 85.4
In: 28.3	In: 14	In: 28	Lb: 188

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
Cm:				
In:				

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
1	None	1 meter

Product: Disc Drive with Two Tape Drives**No. 7914TD**

Responsible Support Division: Disc Memory Division, Boise, Idaho

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
120	108-126	16		1920
240	216-252	8		1920

Surge Current Duration: _____

OPERATING FREQUENCIES

50 Hz nominal, 47.5 - 55
60 Hz nominal, 57 - 66

CIRCUIT BREAKER REQUIRED

SIZE TYPE

LINE-CONDUCTED TRANSIENTS (VOLTS)

Oscillatory wave (100 Hz ringing wave): 1.5 kV, and 50 A
Unidirectional wave (one 20us pulse) : 1 kV

LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

PHASE ANGLE IMBALANCE(%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE
10V peak-peak

HARMONIC CONTENT (DISTORTION)(%)

5

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)TIME (M/SEC) CYCLES
one-halfPOWER FAIL
THRESHOLD VOLTAGEDROP OUT TURN ON
("Overload")Dec 86
2-DD-4

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:	C: 10 - 40	C: -40 to 60
F:	F: 50 - 104	F: -40 to 140

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
	20 - 80, with	10 - 90, with
	max .015 lb/water	max wet bulb
	per lb/dry air.	temp 25.6C
		(78F).

ALTITUDE

OPERATING and NON-OPERATING
M: 0 - 3048
F: 0 - 10000

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)-----
1

ESD (VOLTS)

1.5 kV-----
AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)		COPPER CORROSION (Angstroms/Yr)	
Recommended	Marginal	Recommended	Marginal

AIR CONDITIONING (HEAT GENERATION)

BTUs/hr	KCALs/hr
5546	1398

Product: Disc Drive with Two Tape Drives

No. 7914TD

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm:	Cm:	Cm:	Kg: 454.6
In:	In:	In:	Lb: 1,002

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 161.3	Cm: 63.5	Cm: 81.3	Kg: 339.4
In: 63.5	In: 25	In: 32	Lb: 748

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
Cm:				
In:				

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
------------------	-------------------	--------------------------------

Product: Disc Drives, With No Accessories**No. 7933/35**

Responsible Support Division: Disc Memory Division, Boise, Idaho

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
120	108-132	13		1560
208	188-228	7.6		1581
220	198-242	7.4		1628
240	216-264	6.9		1656

Surge Current Duration: _____

OPERATING FREQUENCIES

47.5 - 63 Hz

CIRCUIT BREAKER REQUIRED

SIZE TYPE

LINE-CONDUCTED TRANSIENTS (VOLTS)Oscillatory wave: 1.5 kV
Unidirectional wave: 1 kV**LINE-TO-LINE POWER IMBALANCE (%)**

Not Applicable

PHASE ANGLE IMBALANCE(%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

2V peak-peak

HARMONIC CONTENT (DISTORTION)(%)

5

**POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)**

TIME (M/SEC) CYCLES

one-half

**POWER FAIL
THRESHOLD VOLTAGE**DROP OUT TURN ON
("Overload")

Dec 86

Z-DD-7

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C: 20-30	C: 7933: 10-40 7935: 10-32	C: -40 to 65
F: 68-86	F: 7933: 50-104 7935: 50-90	F: -40 to 149

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING	OPERATING	NON-OPERATING
Recommended	Min/Max		M: 0-3000	M: -300 to 15000
	8-80, with max wet bulb temp 25.6C (78F).	5-95, with max wet bulb temp 29.5C (85F).	F: 0-9843	F: -984 to 49213

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)

3

ESD (VOLTS)

15 kV

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)		COPPER CORROSION (Angstroms/Yr)	
Recommended	Marginal	Recommended	Marginal

AIR CONDITIONING (HEAT GENERATION)

BTUs/hr	KCALs/hr
4437	1118

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm:	Cm:	Cm:	Kg: 192
In:	In:	In:	Lb: 423

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 82.5	Cm: 55.2	Cm: 83.4	Kg: 154
In: 32.5	In: 21.7	In: 32.8	Lb: 340

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
Cm:				
In:				

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
------------------	-------------------	--------------------------------



Product: Tape Drive, 800 CPI

No. 7970B

Responsible Support Division: Greeley Division, Greeley, Colorado

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
115	104-126	4.24		488
230	207-253	1.50		400

Surge Current Duration: _____

OPERATING FREQUENCIES

48 - 66 Hz

CIRCUIT BREAKER REQUIRED

SIZE
20A

TYPE
STD

LINE-CONDUCTED TRANSIENTS (VOLTS)

3 kV or 150A, whichever is greater

LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

PHASE ANGLE IMBALANCE(%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

Not Available

HARMONIC CONTENT (DISTORTION)(%)

Not Available

**POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)**

TIME (M/SEC) CYCLES

20 1 at 50 Hz

**POWER FAIL
THRESHOLD VOLTAGE**

DROP OUT TURN ON
("Overload")

Not Available

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C: Determined	C: 0 - 55	C:
by spec of		Not Available
F: tape, or	F: 32 - 131	F:
other device		
in system.		

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
Not Available	20-80	Not Available

ALTITUDE

OPERATING	NON-OPERATING
M: 3,050	M: 15,250
Ft:10,000	Ft:50,000

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)

1

ESD (VOLTS)

5kV

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)		COPPER CORROSION (Angstroms/Yr)	
Recommended	Marginal	Recommended	Marginal

AIR CONDITIONING (HEAT GENERATION)

BTUs/hr	KCALs/hr
1666	420

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT -----	WIDTH -----	DEPTH -----	WEIGHT -----
Cm: 76.2	Cm: 71.12	Cm: 63.5	Kg: 71.7
In: 30	In: 28	In: 25	Lb: 158

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT -----	WIDTH -----	DEPTH -----	WEIGHT -----
Cm: 61	Cm: 48.3	Cm: 30.5	Kg: 63.56
In: 24	In: 19	In: 12	Lb: 140

SERVICE CLEARANCE NEEDED

	FRONT -----	REAR -----	LEFT SIDE -----	RIGHT SIDE -----
Cm:	48.3	0	0	0
In:	19	0	0	0

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
48 In. 122 Cm.	120 In. 305 Cm.	Male Female Nema 15-2

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
Not Available		

Product: Tape Drive, 1600 CPI

No. 7970E

Responsible Support Division: Greeley Division, Greeley, Colorado

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
115	104-126	4.24		488
230	207-253	1.50		400

Surge Current Duration: _____

OPERATING FREQUENCIES

48 - 66 Hz

CIRCUIT BREAKER REQUIRED

SIZE	TYPE
20A	STD

LINE-CONDUCTED TRANSIENTS (VOLTS)

3 kV or 150A, whichever is greater

LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

PHASE ANGLE IMBALANCE (%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL	WORST CASE
Not Available	

HARMONIC CONTENT (DISTORTION) (%)

Not Available

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (M/SEC)	CYCLES
20	1 at 50Hz

POWER FAIL
THRESHOLD VOLTAGE

DROP OUT ("Overload")	TURN ON
--------------------------	---------

Not Available

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Z-TD-4

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C: Determined by	C: 0-55	C:
spec of other		Not Available
F: equipment in system.	F: 32-131	F:

RELATIVE HUMIDITY, Non-Condensing, %-----
ALTITUDE

OPERATING		NON-OPERATING	
Recommended	Min/Max	OPERATING	NON-OPERATING
		M: 0-3,050	M: 0-15,250
Not Available	20-80	F: 0-10,000	F: 0-50,000

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)

ESD (VOLTS)

1-----
5 kV-----
AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)		COPPER CORROSION (Angstroms/Yr)	
Recommended	Marginal	Recommended	Marginal

AIR CONDITIONING (HEAT GENERATION)

BTUs/hr	KCALs/hr
1666	420

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 76.2	Cm: 71.12	Cm: 63.5	Kg: 71.7
In: 30	In: 28	In: 25	Lb: 158

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 61	Cm: 48.3	Cm: 30.5	Kg: 63.56
In: 24	In: 19	In: 12	Lb: 140

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
Cm:	48.3	0	0	0
In:	19	0	0	0

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female
48 In. 122 Cm.	120 In.	Nema 15-2

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
1	7 meters	.5 meter

Product: Tape Drive, 6250/1600 CPI

No. 7976

Responsible Support Division: Greeley Division, Greeley, Colorado.

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
117	100-128	15		1755
220	187-242			
240	204-264			

Surge Current Duration: _____

OPERATING FREQUENCIES

50 Hz nominal, range 47.5 - 52.5
60 Hz nominal, range 57 - 63

CIRCUIT BREAKER REQUIRED

SIZE TYPE
20A STD

LINE-CONDUCTED TRANSIENTS (VOLTS)

LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

PHASE ANGLE IMBALANCE(%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

Not Available

HARMONIC CONTENT (DISTORTION)(%)

Not Available

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (M/SEC) CYCLES

1/2 Cycle in 10

POWER FAIL
THRESHOLD VOLTAGE

DROP OUT TURN ON
("Overload")

Not Available

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Z-TD-7

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:	C: 13 - 29	C: 2 - 50
F:	F: 55 - 84	F: 35 - 122

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	Any Non-Condensing
	25 - 60	

ALTITUDE

OPERATING	NON-OPERATING
M: 0-1981	M: 0-15,300
Ft: 0-6500	Ft: 0-50,000

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)

1

ESD (VOLTS)

10 kV

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)		COPPER CORROSION (Angstroms/Yr)	
Recommended	Marginal	Recommended	Marginal

AIR CONDITIONING (HEAT GENERATION)

BTUs/hr	KCALs/hr
5992	1510

Product: Tape Drive, 6250/1600

No. 7976

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 187.96	Cm: 83.82	Cm: 111.8	Kg: 356
In: 74	In: 33	In: 44	Lb: 786

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 158.5	Cm: 62.3	Cm: 90.5	Kg: 254
In: 62.4	In: 24.5	In: 35.6	Lb: 560

SERVICE CLEARANCE NEEDED

	FRONT	REAR	SIDES
-----	-----	-----	-----
Cm:	54.6	54.6	81.3
In:	21.5	21.5	32

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female
Nema 5-20		
20A, 125V		
Male		

HP-IB DEVICE LOADS

SHIPPED	OPTIONAL	INTERNAL HP-IB
LOADS	RANGE	CABLE LENGTH
2 Loads	1, 2, 4 or any combination:	2 meters
HP-IB Load Resistor Chips	3 (2 + 1)	
Two on board	4 or (3 + 1)	
Standard - 2 Load		
part no. 1810-0410	5 (4 + 1) or (2 + 3)	
4 Load	6 (4 + 2)	
part no. 1810-0409		



Product: 300 LPM Printer

No.2563A

Responsible Support Division: Boise Division, Boise, Idaho.

Page 1. ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE (V)		CURRENT CONSUMPTION (AMPS)		POWER (VOLT-AMPS)
Nominal	Range	Steady-State	Surge	
100	90-105	2.3	6	230
120	108-126	2	5	230
220	198-231	1.1	2.73	230
240	216-252	1	2.5	230

OPERATING FREQUENCIES

47 to 66 Hz

CIRCUIT BREAKER REQUIRED

SIZE TYPE
15-20A STD

LINE-CONDUCTED TRANSIENTS (VOLTS)

3000 V Ringing Wave; plus or minus 1.5 kV, 60 us duration

LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

PHASE ANGLE IMBALANCE (%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE
Not Available

HARMONIC CONTENT (DISTORTION) (%)

Not Available

**POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)**

TIME (M/SEC) CYCLES
20

THRESHOLD VOLTAGE

DROP OUT TURN ON
Not Available

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Z-LP-1

Page 2. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C: 10 - 50	C: 10 - 50	C: -55 to 75
F: 50 - 122	F: 50 - 122	F: -67 to 167

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
25 - 85	5 - 95	Not Available

ALTITUDE

OPERATING	NON-OPERATING
M: 4600	M: 15300
Ft: 15000	Ft: 50000

NOTE: These specs apply to the printer. The PAPER used may have tighter specs. It is anticipated that the paper may jam at the extremes of these limits.

EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)-----
1ESD (VOLTS)

15 kV limit without affecting OPERATION; 25 kV limit without DAMAGE to printer.

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)		COPPER CORROSION (Angstroms/Yr)	
Recommended	Marginal	Recommended	Marginal

AIR CONDITIONING (HEAT GENERATION)

BTUs	KCALs
853 Max	214 Max

Page 3. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 47	Cm: 77.15	Cm: 62.55	Kg: 39
In: 18.5	In: 30.375	In: 24.625	Lb: 86

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
Cm: 27.4*	Cm: 60	Cm: 45	Kg: 34*
In: 10.75*	In: 23.6	In: 17.75	Lb: 75*

* With optional stand, add 72 cm (28.4 in.) height and 272 kg (60 lb) weight.

SERVICE CLEARANCE NEEDED

FRONT	REAR	LEFT SIDE	RIGHT SIDE
-----	-----	-----	-----
Cm: Not Applicable	67	15.2	15.2
In: Not Applicable	24	6	6

POWER CABLES (LENGTH)

STANDARD	OPTIONAL	CONNECTOR TYPE	
		Male	Female
2 Meters	4 Meters	NEMA	CEE 22V
6 Feet	15 Feet	5-15P	

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
-----	-----	-----
1	Max 7	None

Product: 600/900 LPM Printer

No. 2565/66

Responsible Support Division: Boise Division, Boise, Idaho.

Page 1. ELECTRICAL SPECIFICATIONS: POWER AND HEAT

INPUT VOLTAGE/FREQUENCY

Nominal	100V @ 50/60Hz	120V @ 50/60Hz	220V @ 50/60Hz	240V @ 50/60Hz
Range	90-105V, 47-63Hz	108-126V, 47-63Hz	198-231V, 47-63Hz	216-252V, 47-63Hz

CURRENT, in AMPERES

Typical Steady-State	Not Avail	Not Avail	Not Avail	Not Avail
Maximum Steady-State*	5.5	4.6	2.5	2.3
Surge / Duration in Hz	Not Avail	70A, 2Hz	Not Avail	Not Avail

POWER USE, in VOLT-AMPS

Typical	Not Avail	Not Avail	Not Avail	Not Avail
Maximum	550	550	550	550

POWER USE, in WATTS

Typical	Not avail	Not Avail	Not Avail	Not Avail
Maximum	550	550	550	550

HEAT GENERATION

Typical: BTUs/Hr

	Not Avail	Not Avail	Not Avail	Not Avail
KCALs/Hr				
Maximum: BTUs/Hr	1877	1877	1877	1877
KCALs/Hr	473	473	473	473

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Page 2. OTHER ELECTRICAL SPECIFICATIONS

POWER LINE SUSCEPTIBILITY TO CONDUCTED TRANSIENTS

Voltage Transients		Frequency Transients		Spike Transients
% of Nominal	Duration, millisecc	% of Nominal	Duration, millisecc	Amplitude, in volts: 3k
				Rise Time, microsec
				Duration, microsec

LINE-TO-LINE POWER IMBALANCE (%)

Not Applicable

NEUTRAL-GROUND VOLTAGE

NOMINAL WORST CASE

Not Available

HARMONIC CONTENT (DISTORTION)(%)

Not Available

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (M/SEC)	CYCLES
20	2 at 50Hz

CIRCUIT BREAKER REQUIRED

SIZE	TYPE
20A	Std.

* Conditions Under Which Maximum Steady-State Current Was Measured:

Page 3. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C: 10 - 50	C: 0 - 55	C: -55 to 75
F: 50 - 122	F: 32 - 131	F: -67 to 167

NOTE: The PAPER used in the printer may have more stringent limits.

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
30 - 50*	20 - 80	5 - 95
20 - 80**		

* For 18-pound or lighter paper.

** For paper heavier than 18-pound. These ranges specified to minimize (but not eliminate) paper jams.

ALTITUDE

OPERATING	NON-OPERATING
M: 4600	M: 15300
Ft: 15000	Ft: 50000

RADIATED EMI SUSCEPTIBILITY
(VOLTS/METER @ 14kHz - 1GHz)

1

ESD SUSCEPTIBILITY (VOLTS)

15 kV limit without affecting
OPERATION; 25 kV limit without
DAMAGE to printer.

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cu.mtr.)

COPPER CORROSION (Angstroms/Yr)

Page 4. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT -----	WIDTH -----	DEPTH -----	WEIGHT -----
Cm: 129.5	Cm: 120.7	Cm: 106.7	Kg: 215.4
In: 51	In: 47.5	In: 42	Lb: 475

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT -----	WIDTH -----	DEPTH -----	WEIGHT -----
Cm: 110	Cm: 98.3	Cm: 63.5	Kg: 181.8
In: 43.3	In: 38.7	In: 25	Lb: 400

SERVICE CLEARANCE NEEDED

FRONT -----	REAR -----	LEFT SIDE -----	RIGHT SIDE -----
Cm: Not Applicable	60	63.5	15.25
In: Not Applicable	24	25	6

POWER CABLES (LENGTH in Centimeters and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE	
		Male	Female
183 Cm	None	NEMA 515P	CEE 22
72 In.			

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	INTERNAL HP-IB CABLE LENGTH
1	0 - 7	None

**Product: Board Test System (Controller)****No. 3065C**

Responsible Support Division: Manufacturing Test Division, Loveland, Colorado

Page 1. ELECTRICAL SPECIFICATIONS: POWER AND HEAT**INPUT VOLTAGE/FREQUENCY**

Nominal	200V 50 or 60Hz	208V, 3Phase 60Hz	220V 50Hz	240V 50Hz	240V Center-Tapped 50 or 60 Hz
Range	180-210V 49.5-50.5Hz 59.4-60.6Hz	187-218V 59.4-60.6Hz	198-231V --49.5-50.5Hz--	216-252V	216-252V 49.5-50.5Hz 59.4-60.6Hz

CURRENT, in AMPERES**PHASE A, or 1-PHASE:**

Maximum Steady-State*	15	15	15	15	15
-----------------------	----	----	----	----	----

Inrush/Duration in Hz

PHASE B:

Maximum Steady-State*	NA	15	NA	NA	NA
-----------------------	----	----	----	----	----

Inrush/Duration in Hz

PHASE C:

Maximum Steady-State*	NA	15	NA	NA	NA
-----------------------	----	----	----	----	----

Inrush/Duration in Hz

POWER USE, in VOLT-AMPS

Maximum

POWER USE, in WATTS

Maximum

HEAT GENERATION

Maximum: BTUs/h	5000	5000	5000	5000	5000
kcal/h	1260	1260	1260	1260	1260

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Page 2. OTHER ELECTRICAL SPECIFICATIONS

POWER LINE SUSCEPTIBILITY TO CONDUCTED TRANSIENTS

Voltage Transients		Frequency Transients		Spike Transients
% of Nominal	Duration, ms	% of Nominal	Duration, ms	Amplitude, in volts
				Rise Time, microseconds
				Duration, microseconds

LINE-TO-LINE POWER IMBALANCE (%)

NEUTRAL-GROUND RESISTANCE

NOMINAL WORST CASE

1 Ohm

HARMONIC CONTENT (VOLTAGE DISTORTION) %

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (ms) CYCLES

CIRCUIT BREAKER SUGGESTED

SIZE TYPE

* Conditions Under Which Maximum Steady-State Current Was Measured:

Not measured; values are theoretical, based on maximum system configuration and worst-case operating conditions.

Page 3. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE, Degrees			
OPERATING		NON-OPERATING	
Recommended	Minimum/Maximum		
C:	C: 10 - 40	C:	
F:	F: 50 - 104	F:	
RELATIVE HUMIDITY, Non-Condensing, %		ALTITUDE	
OPERATING		OPERATING	NON-OPERATING
Recommended	Min/Max	m:	m:
		ft:	ft:
	20-80		
RADIATED EMI SUSCEPTIBILITY		ESD SUSCEPTIBILITY (VOLTS)	
(VOLTS/METRE @ 14 kHz - 1 GHz)			
1			

AIRBORNE CONTAMINATION	
PARTICULATES (micrograms/cubic metre)	COPPER CORROSION (Angstroms/Year)

Page 4. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm:	cm:	cm:	kg: 330
in:	in:	in:	lb: 727

UNCRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: 163	cm: 74	cm: 81	kg: 264
in: 64	in: 29	in: 32	lb: 582

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
	-----	-----	-----	-----
cm:	100	100	100	---
in:	36	36	36	---

POWER CABLES (LENGTH in Centimetres and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-IB DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	SHIPPED LENGTH	INTERNAL HP-IB CABLE LENGTH
-----	-----	-----	-----

Product: Board Test System (Test Station)

No. 3065H

Responsible Support Division: Manufacturing Test Division, Loveland, Colorado

Page 1. ELECTRICAL SPECIFICATIONS: POWER AND HEAT

INPUT VOLTAGE/FREQUENCY

Nominal	200V 50 or 60Hz	208V, 3Phase 60Hz	220V 50Hz	240V 50Hz	240V Center-Tapped 50 or 60 Hz
Range	180-210V 49.5-50.5Hz 59.4-60.6Hz	187-218V 59.4-60.6Hz	198-231V --49.5-50.5Hz--	216-252V	216-252V 49.5-50.5Hz 59.4-60.6Hz

CURRENT, in AMPERES

PHASE A, or 1-PHASE:

Maximum Steady-State*	20	20	15	15	15
Inrush/Duration in Hz		35			

PHASE B:

Maximum Steady-State*	NA	20	NA	NA	NA
Inrush/Duration in Hz		35			

PHASE C:

Maximum Steady-State*	NA	20	NA	NA	NA
Inrush/Duration in Hz		35			

POWER USE, in VOLT-AMPS

Maximum

POWER USE, in WATTS

Maximum

HEAT GENERATION

Maximum: BTUs/h	5000	5000	5000	5000	5000
kcal/s/h	1260	1260	1260	1260	1260

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Page 2. OTHER ELECTRICAL SPECIFICATIONS

POWER LINE SUSCEPTIBILITY TO CONDUCTED TRANSIENTS

Voltage Transients		Frequency Transients		Spike Transients
% of Nominal	Duration, ms	% of Nominal	Duration, ms	Amplitude, in volts
				Rise Time, microseconds
				Duration, microseconds

LINE-TO-LINE POWER IMBALANCE (%)

NEUTRAL-GROUND RESISTANCE

NOMINAL	WORST CASE
---------	------------

1 Ohm

HARMONIC CONTENT (VOLTAGE DISTORTION) %

POWER FAIL SENSITIVITY
(WORST CASE VOLTAGE)

TIME (ms)	CYCLES
-----------	--------

CIRCUIT BREAKER SUGGESTED

SIZE	TYPE
------	------

* Conditions Under Which Maximum Steady-State Current Was Measured:

Not measured; values are theoretical, based on maximum system configuration and worst-case operating conditions.

Page 3. ENVIRONMENTAL SPECIFICATIONS

AMBIENT TEMPERATURE, Degrees

OPERATING		NON-OPERATING
Recommended	Minimum/Maximum	
C:	C: 18 - 28	C:
F:	F: 64 - 82	F:

RELATIVE HUMIDITY, Non-Condensing, %

OPERATING		NON-OPERATING
Recommended	Min/Max	
	5-80	

ALTITUDE

OPERATING	NON-OPERATING
m:	m:
ft:	ft:

RADIATED EMI SUSCEPTIBILITY
(VOLTS/METRE @ 14 kHz - 1 GHz)-----
1ESD SUSCEPTIBILITY (VOLTS)

AIRBORNE CONTAMINATION

PARTICULATES (micrograms/cubic metre)

COPPER CORROSION (Angstroms/Year)

Page 4. PHYSICAL SPECIFICATIONS

CRATED DIMENSIONS AND WEIGHT

HEIGHT	WIDTH	DEPTH	WEIGHT: Bay 1 / Bay 2
-----	-----	-----	-----
cm:	cm:	cm:	kg: 391 / 301
in:	in:	in:	lb: 862 / 664

UNCRATED DIMENSIONS AND WEIGHT (Bay 1 / Bay 2)

HEIGHT	WIDTH	DEPTH	WEIGHT
-----	-----	-----	-----
cm: 163 / 163	cm: 74 / 64	cm: 107 / 81	kg: 345 / 234
in: 64 / 64	in: 29 / 25	in: 42 / 32	lb: 761 / 516

SERVICE CLEARANCE NEEDED

	FRONT	REAR	LEFT SIDE	RIGHT SIDE
-----	-----	-----	-----	-----
cm:	100	100	100	---
in:	36	36	36	---

POWER CABLES (LENGTH in Centimetres and Inches)

STANDARD	OPTIONAL	CONNECTOR TYPE
		Male Female

HP-18 DEVICE LOADS

SHIPPED LOADS	OPTIONAL RANGE	SHIPPED LENGTH	INTERNAL HP-18 CABLE LENGTH
-----	-----	-----	-----