HEWLETT-PACKARD GENERAL SYSTEMS USERS GROUP 1980

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CLEAN POWER LINES
HOW TO KEEP YOUR COMPUTER SYSTEM OPERATIONAL

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H/P COMPUTER SYSTEMS
COURSE OUTLINE
26 FEBRUARY 1980

I. Introduction

"Clean Power" what does it mean to you?

1. No errors-
2. No failures of equipment-
3. Saves $$$ → means more profits

II. Technical

A. You have a problem - voltage transients, failure of parts and errors in your H/P computer systems as well as terminals and other computer equipment.

B. What are voltage transients?

C. Where do transients occur?

D. What causes transients?

E. What is the solution?

HP3000 Series 30
HP3000 Series 33
HP3000 Series 111 } Transtector System P/N CPS 120W/ACP 3000-120W (Branch Panel)

Terminals and other > ACP100B

F. How does it work?

G. How fast does it work?

III. Common Questions and Answers

A. Doesn't the manufacturer build-in this protection?

Basically no! They don't put enough due to cost factors. Noise filters (EMI)

B. Why don't gas tubes / spark gaps / mov's work?

They are basically to slow and allow for a high voltage overshoot.

C. Why don't Regulation/Isolation transformers work? (Eng. Note 9110)

They are primarily designed to regulate the slow moving A.C. voltage and to suppress noise (high frequency, low energy).

D. Why don't dedicated lines give me clean power? (Eng. Note 9112)

They protect you from transients inside the building but allow for the more damaging outside to come directly in (lightning, power company & switching surges).

E. L/C filters, what do they do?

They suppress "noise" that rides on the sine wave (low energy, high frequency).

F. Shall I buy an UPS (Uninterrupted Power System) to protect me against transients? (Eng. Note 9111)

1. No! Too costly for transient protection.

2. The input to the UPS is exposed to high energy transients.

3. When you're on By-Pass (UPS not on-line for whatever reason), the computer center is then directly exposed to high energy transients.

G. What type of grounds do I need?

1. Good - single point.

2. The heart of clean power.

I. INTRODUCTION

"Clean Power" what does it mean to you?

1. No errors-
2. No failures of equipment-
3. Saves $$$ → means more profits

II. TECHNICAL

With the quantum leaps in digital logic technology presently occurring in the electronics industry, it seems only a matter of time before the entire world will be microprocessor controlled. Great powers of observation are not required to discover integrated circuits and semiconductor chips contained in all manner of electronic and electromechanical products from the very latest generation of high-powered computer hardware to watches, cameras, and, yes, even sewing machines.

Much of the new capability in the semiconductor industry is related directly to the component manufacturer's new ability to dramatically increase circuit density. The increasing density thus allows for more computer power, memory storage, or control functions in much less space. Recent announcements by a major vendor of computer hardware heralds advances in their semiconductor chip memory with the development of a ¼" x ¼" chip capable of 64K bit memory storage.

While these advances in integrated circuit and semiconductor technology are primarily responsible for many new and useful products as well as greatly increased productivity of existing products, it is ironic to note that the advances in circuit density which allow these important innovations are also causing monumental headaches for both field service personnel and customers alike. In short, increasing circuit density and decreasing tolerance to voltage fluctuations go hand in hand.

An examination of the table in Fig. 1 indicates that failure of sensitive components isn't the only aspect of voltage transients. Upset of the logic in the digital circuitry can occur with transient energy levels as low as 1×10^{-9} joules. These figures are significant particularly when compared with the degenerating electrical environment available to the users of highly sophisticated hardware.

In addition to the single-occurrence destruction or logic upset, constant exposure of a semiconductor to high-transient environments can cause an erosion or degrading of that semiconductor. This type of degradation might be compared to a tiny "micro bullet hole" fired through the chip (Figs. 2 and 3).

This constant erosion of solid-state semiconductors and integrated circuits is of prime concern to users and manufacturers of electronic equipment containing these components. The degeneration of these electronic components in circuits is attributed directly to an often misunderstood phenomenon known as transient voltage. Observations by hybrid generation recording equipment allows an exact definition of transients (pulse width and amplitude only) to be high-speed voltages superimposed on the sine wave of the AC power. It is important to note at this point that these high speed overvoltages which cause the disruption of operation or destruction of these electronic devices are not restricted to AC power lines but may enter delicate circuitry (i.e., signal or data lines) by any pathway provided, such as coaxial cables, dedicated phone lines, etc., and even ground.

Various unsuccessful attempts have been made to eliminate the destructive transient from the AC power and signal lines. However, the speed, amplitude, pulse width, and energy characteristics of the transient create a complex problem. The solution need not be complex; however, isolation of the vulnerable electronic component from these destructive overvoltages is the solution.

CAUSATIVE FACTORS

Meteorological conditions that precipitate lightning storm activity are, from a dollar-volume standpoint, the single most destructive transient source. In many cases the actual damage to a computer mainframe from a nearby lightning storm has caused losses in excess of $100,000.

Power companies, due to variations in demand, are required to switch their generators and lines to meet their customers' needs. Each switching operation results in a transient voltage surge that spreads with a ripple effect through the entire affected power grid. In addition, load disconnects and on-off switching by other customers on the same feeder will often produce damaging high-speed overvoltages.

In-plant operations such as air conditioning, refrigeration, elevators, circuit-breaker load disconnects, and on-off cycling of large motors will introduce transients to the AC power system.

It is clear that there is an enormous need for a transient protection system that will respond to these high-speed overvoltages and shunt them safely away from the equipment. This system must incorporate an extremely fast response time to provide adequate protection for logic and memory circuitry and a design that allows simultaneous transient suppression on all phases of the power source. Additional considerations are voltage clamping point, methods of installation, and the amount of dissipation capacity as it relates to the equipment it is designed to protect.

FIVE MAJOR CONSIDERATIONS FOR PROTECTING FACILITY AND EQUIPMENT

1. Response Time

A response time of high-speed/low nanoseconds is important because of the high-speed rise time of the induced transients or surges. Listed below are some typical rise times for three transient-generating sources.

A. Lightning: 600V - 10kV/microsecond

B. Power Line Surges: 100V - 300V/microsecond

C. Electromagnetic Pulse (EMP): 5kV/nanosecond

2. Suppression (Power) Capability

Capability of 100,000 to 1,500,000 watts and ability of suppressing 15,000 to 50,000 amperes induced on the AC service line should be handled. The data entry lines (signal) can experience 5,000 to 10,000 watts and energies of 3,000 to 4,000 amperes before the lines explode. Experience and test measurements show these energies do exist.

3. Voltage Suppression and Clamping Ratio

It is important to consider low-voltage threshold and a less than 1 to 1.5 clamping ratio. The device can turn on and start suppressing at 120 percent of the nominal line and, at maximum power, cannot exceed 150 percent of the nominal line; a clamping ratio of 1 to 1.5. If a protector were not to begin suppressing at low voltage threshold, it would allow the low-level surges through to damage equipment.

4. High Reliability

The device should be totally solid-state and failsafe, with redundant calibrated circuitry, to be highly reliable.

5. Operation

This system should be automatic or resettable. If the nature of a system were to preclude an interruption in service that is, if one could not afford to be shut down, an automatic device would be required.

SOLUTIONS

1. Isolation Transformers/Voltage Regulators (Ref. Eng. Note 9110)

Originally thought to provide some measure of protection from transients were the isolation transformers/voltage regulators. However, further scientific studies have shown that these devices, when operating at near saturation levels, act as virtual accelerators for the transient voltage, capacitively coupling the transient from input to output. A regulator's response time is, at best, in the low milliseconds, not fast enough to catch the damaging nanosecond transients. These devices were designed for slow-moving line surges and high or low line conditions. Without additional protection, the destructive transient problem could be compounded.

Two basic systems for stored energy (and isolation to the semiconductors and integrated circuits from transients entering these devices over the AC power lines) are the Motor Generator Set and the solid-state Uninterruptible Power System (UPS). If the problem is voltage transients only, the Motor Generator Set and UPS would be very expensive ways to give a system transient protection. These systems are primarily designed for low voltage, no voltage, and short time loss of voltage. The energy dissipated to run these systems must also be considered.

2. Motor Generator Set

Though less costly than a solid-state UPS, the Motor Generator Set has certain inherent problems associated with dispersion of the kinetic energy stored in the flywheel portion of the set. Operational reliability, space, noise, special foundations, mean-time-to-repair, and routine maintenance of the rotating portion add to the operational cost.

3. Solid-State UPS (Ref. Eng. Note 9111)

A UPS is a reliable source of uninterruptible power. Basic considerations must be given to the economics of these devices due to the high initial cost in comparison to other stored energy systems. An investigation of the solid-state circuitry of the UPS would show that the UPS itself is exposed to failure due to voltage transients.

One basic drawback to the UPS for protecting against transients is that the input circuits are exposed to the damaging transient surges. When these circuits fail, the bypass switch transfers and the raw AC power is then fed directly into the computer system or other sensitive electronic device that the UPS may be supplying power for.

4. Solid-State Suppression Systems

Clearly emerging from all perspectives as a leader in the field of transient protection is the two-terminal, solid-state multiple-component suppression system. This unit sits in parallel across the line monitoring and responding in an incredibly short time (typically 5 nanoseconds) to transient voltage occurrences and absorbing the damaging energy before it can complete its path through the equipment.

Typical applications are in the AC power lines feeding the computer, at the branch panel feeding the computer, or at the entrance to the facility. This protects the AC side. The other area that needs protection is signal lines/telephone lines or interface. In any case, both AC and signal lines/interface must be protected with devices which have some of the previously listed clear-cut characteristics.

5. Dedicated Lines (Ref. Eng. Note 9112)

If a computer center is fed from a direct dedicated line, some transient problems are eliminated. The dedicated line prevents internal (user generated) transients, such as induction motors starting and stopping, from reaching the computer center. However, if the end user connects any inductive load on this dedicated line, such as computer center air conditioning, the whole purpose of the dedicated line is destroyed. The problem is that with the dedicated line, external transients, such as lightning, power company switching, and other users on the utility feed, now have a direct path to the computer center. Unfortunately, these external transients, although less frequent, are of a much higher energy content than the majority of internally caused transients.

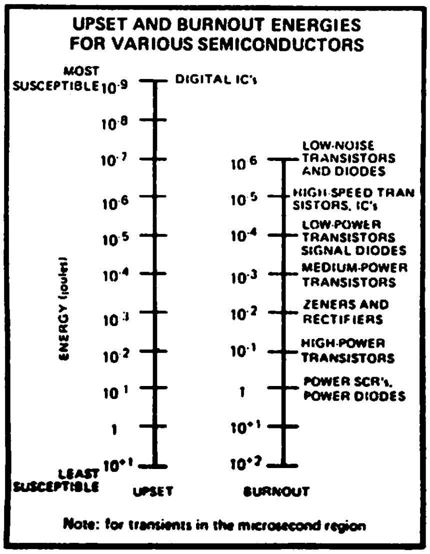

Fig. 1

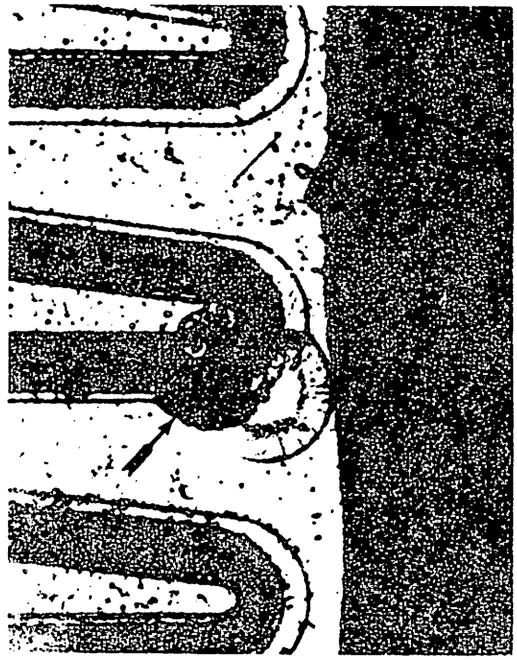

Fig. 2

Fig. 3

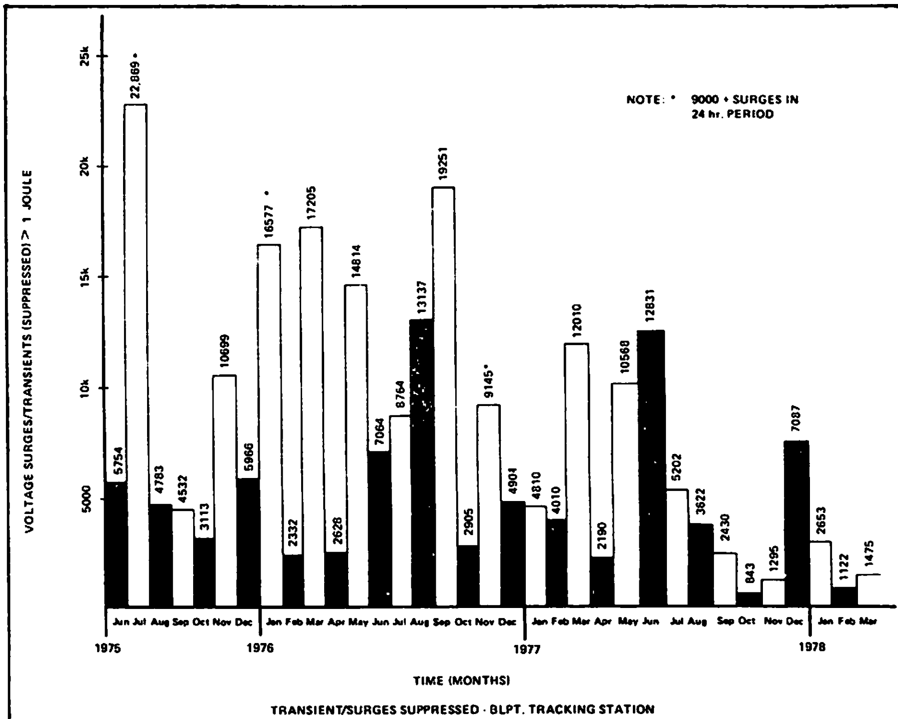

Fig.

WHY VOLTAGE REGULATING/ISOLATING TRANSFORMERS DO NOT SUPPRESS HIGH-SPEED, HIGH-ENERGY TRANSIENTS?

Field experience frequently shows that voltage regulating/isolating transformers let through high-speed, high-energy, voltage transients. These transients are the type that damage or cause errors in computer equipment.

Why then, do the major manufacturers of these products state they suppress transients? The answer is straightforward. The regulation/isolation transformer(s) manufactured today specify response times to voltage fluctuations (transients) in milliseconds. In the "real world" of the computer end user, the word "transient" relates to voltage excursions of microsecond and nanosecond duration. At best, the regulator's fastest response time as quoted on a "minicomputer regulator" (ref. 2, 60 Hz service) is 25 milliseconds. Approximately one thousand times slower than the typical transient. The transient that gets through the regulator is high speed and high energy. This transient is not "noise."

What is the difference between a "noise" and a voltage transient (spike, surge, etc.)? The main difference is the amount of energy (joules) in the voltage fluctuation. Most manufacturers of voltage regulators or as they say, "minicomputer regulators" with isolation, have an excellent noise rejection capability both common mode as well as transverse mode. The best published specification for noise attenuation is 120 db for common mode and 60 db for transverse mode (ref. 2). Noise is low energy (less than .5 joule), with voltage peaks that generally do not exceed 3-4 times the peak voltage of the sinewave. A voltage transient is high energy (greater than 4 joules) and has voltage peaks as high as 10 times the peak of the sinewave. The pulse width generally does not exceed a few hundred microseconds (ref. 1).

The "minicomputer regulator" with isolation does suppress some of this voltage transient. But, most of it passes through the "minicomputer regulator" either by transformation, saturation or capacitive coupling. The end result is the computer/processor either errors or fails.

The solution to this problem is both a minicomputer regulator with isolation and a high speed, high energy voltage transient protector, like Transtector Systems' products.

REFERENCES: 1. IEEE, p. 587.1/F, 5/79, "Guide on surge voltages in AC power circuits rated up to 600V."

2. Sola catalogue, 272-006 56 Rev 10-78, 669, 673, Rev 7/79.

3. Topaz catalogue, LT65-1/77, LL46-2/77.

PROTECTION FOR SOLID-STATE UNINTERRUPTIBLE POWER SUPPLIES (UPS)

Due to the frequency of "momentary outages" and voltage fluctuations on commercial power systems, an increasing number of Electronic Data Processing Installations are turning to solid-state uninterruptible power supplies (UPS). Figure 1 shows a typical electrical wiring diagram. The generator is not usually a part of the system except when long-term operations of the UPS is mandatory. An emergency bypass line is typically installed to avoid data losses from operational memory, in the event of a UPS failure. This bypass line is controlled by an electrically quiet static transfer switch (usually a solid state) (SCR). As stated by UPS manufacturers, "the most common UPS malfunctions are shorted SCR's, commutation failures, misfiring of an invertor phase by noise or by instantaneous overloads caused by a failed power component".

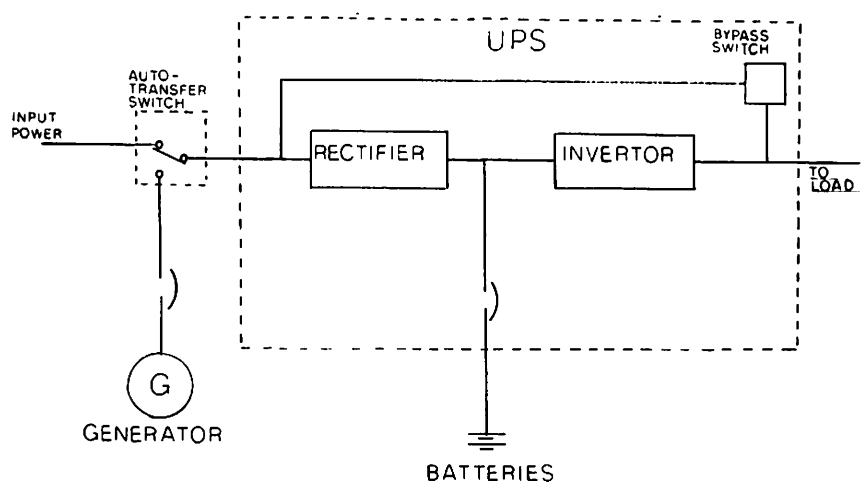

FIGURE 1

When the UPS fails, power is routed to the load via the bypass circuit. This exposes the computer equipment to the unfiltered commercial power. If an undervoltage condition develops, most computer equipment will shutdown normally with only down time experienced. However, if a voltage transient or surge condition develops, the computer equipment will experience a scrambled shutdown with possible memory loss and/or equipment damage.

The installation of a solid state transient suppression system upstream of the UPS provides the necessary dual protection.

1. The transient suppressor protects the (sensitive solid-state) input circuitry of the UPS which is vulnerable to transient voltage conditions. As stated by UPS manufacturers, transients will not pass through the UPS to downstream equipment. However, if the UPS circuitry itself is damaged, power is then switched to the bypass line and the down stream equipment is then directly exposed to the transient activity on the commercial AC power line.

2. If the system does bypass for a non-transient-caused UPS failure the downstream equipment is again protected from the voltage transients.

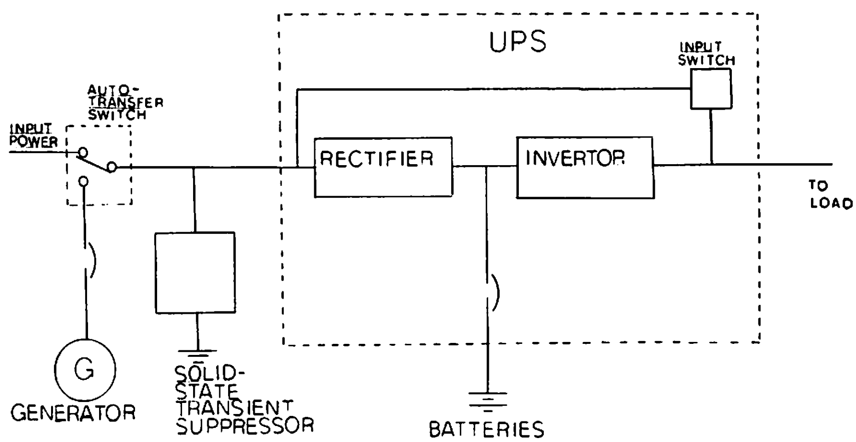

FIGURE 2

In summary, protection systems as shown in Figure 2 will greatly reduce the chance of a UPS failure and protect the downstream equipment should the system go to bypass.

Misconception Regarding "Dedicated Lines" For Computers

It is a common misconception of management and many Engineers that if a computer center is fed from a direct dedicated line (fig.1) from the utility, the computer center will not experience transient power problems. Unfortunately this is not the case. It is true that the dedicated line does isolate the computer center from the power distribution system of the rest of the facility. This will prevent any internal (user generated) transients, such as induction motors starting and stopping, from reaching the computer center. However, if the end user installs any inductive loads, such as computer center air conditioning, on this dedicated line, the whole purpose of the dedicated line is destroyed.

The problem with the dedicated line, even though isolated from internal transients, is that the computer center is vulnerable to external generated overvoltage transients. These transients such as lightning, power company switching, and other utility users on same feeder, now have a direct path to the computer center. Unfortunately, these external transients, although less frequent, are of a much higher energy content than the majority of internally caused transients.

It is our recommendation, that a transient suppression device, capable of handling large amounts of energy, while maintaining a safe voltage level to the computer equipment under transient conditions be installed on this dedicated line.

Dedicated lines are costly and not necessary when transient voltage suppression is used. Fig. 2 shows the transient suppressor installed.

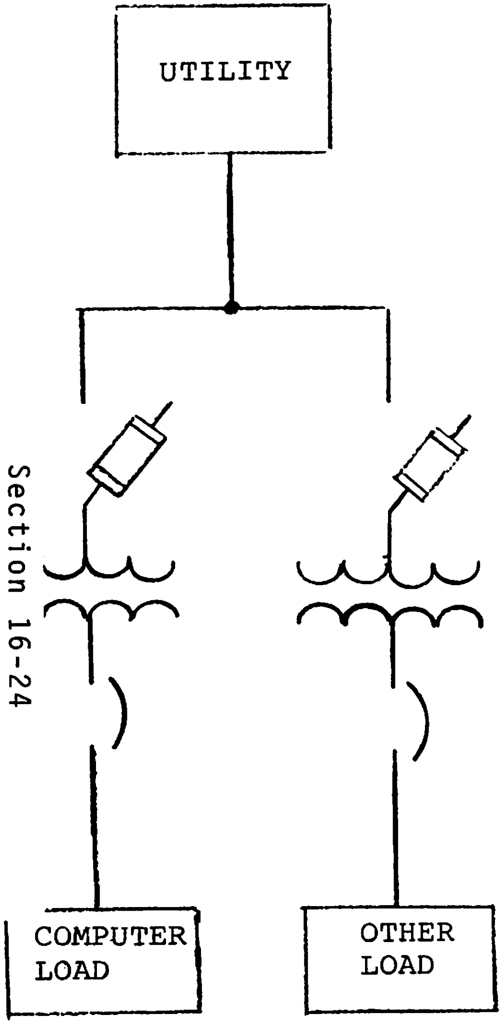

FIG. 1A
DEDICATED LINE

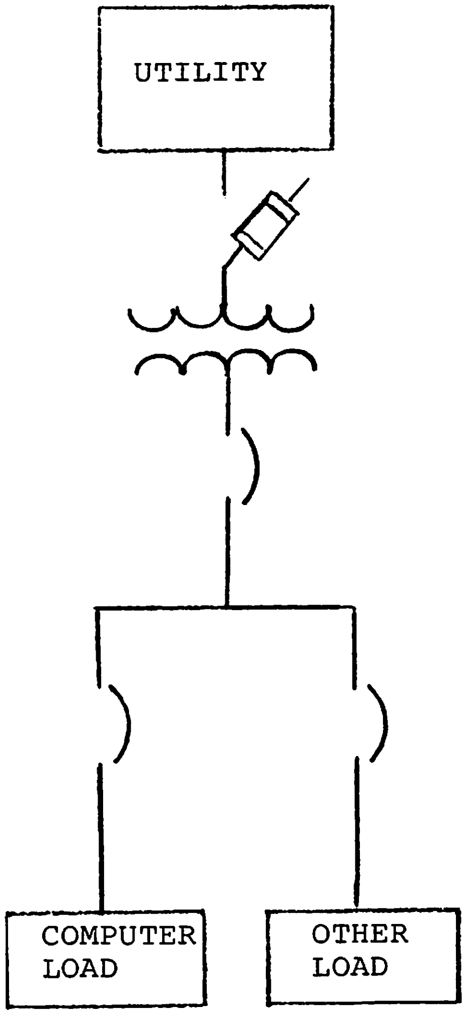

FIG. 1B
NON-DEDICATED LINE

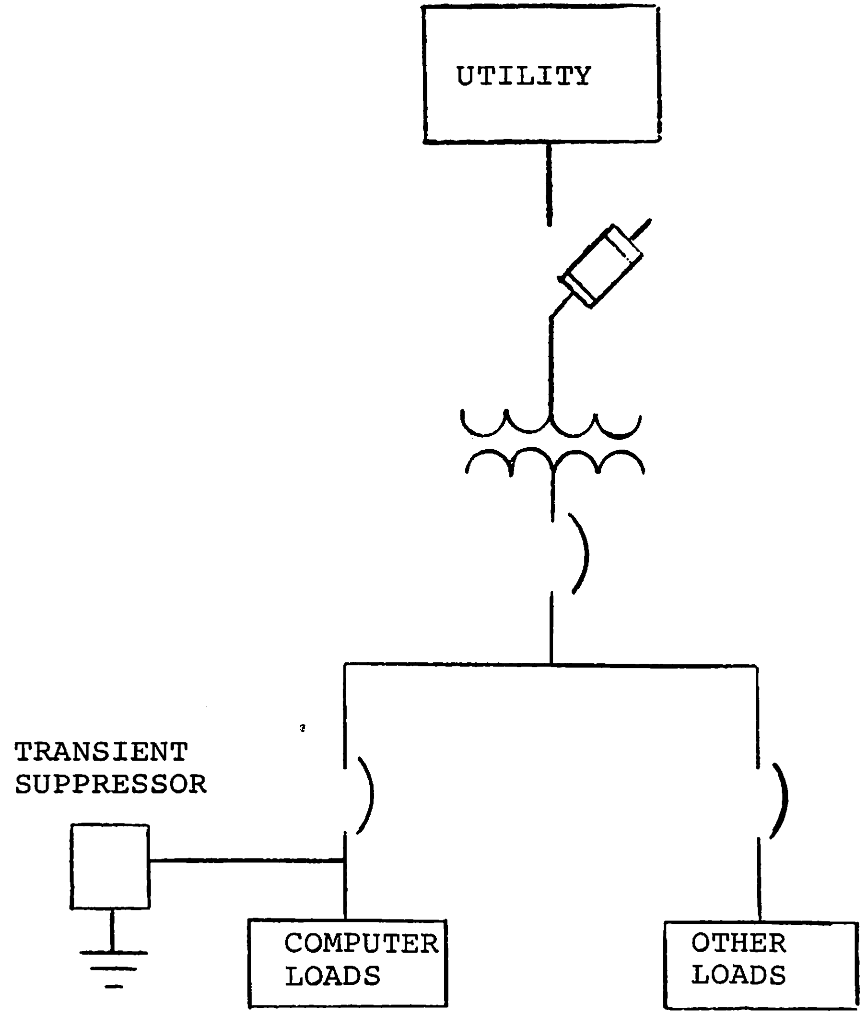

FIG. 2