Power Quality

and Computers on the Farm

Table of Contents

Introduction

Quality of electrical power is becoming an increasingly important issue on farms. This is not a result of changes in power quality delivered to farms, but rather a change in the type of electrical equipment used on farms. Computers and other microprocessor-based equipment that contain electronics can be sensitive to power disturbances, whereas motors and other traditional farm loads are not.

Power quality disturbances can be caused by outside sources such as weather, normal utility operations, neighboring facilities, or on the premises through unsound wiring, improper grounding, or internal equipment such as large motors, variable frequency drives, laser printers, and fax or copy machines.

As agricultural businesses rely more heavily on computers and electronics for their daily operations, the need for high quality power becomes apparent.

Typical farm equipment that requires high quality power includes:

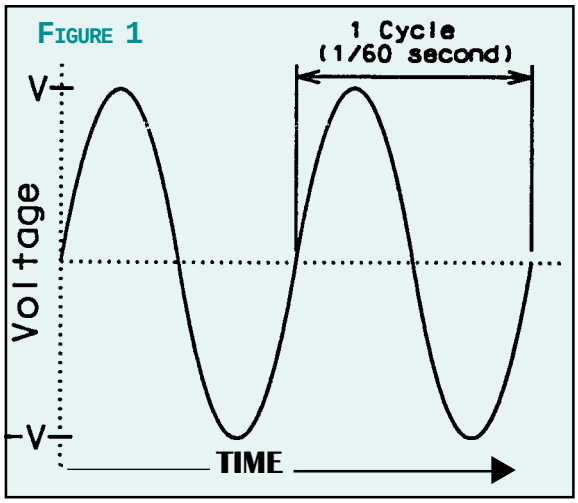
- Computers
- Cow identification systems
- Data acquisition equipment
- Controllers (e.g. for ventilation fans)
- Electronic timers and clocks

Damage to any of this equipment can be costly and inconvenient, and can result in the loss of valuable business information. If proper precautions are taken, equipment damage can be easily avoided.

Power Quality Definition

POWER QUALITY: DEFINITION

Utility power is delivered to your farm at a specified voltage and frequency. High quality power is delivered at or very near the specified voltage (e.g. 120 Volts) and frequency (60 Hz). Perfect power, when viewed through an oscilloscope, looks like the sine wave depicted in Figure 1. Deviation from the specified voltage or frequency can cause operating problems with sensitive electrical equipment. The best gauge of power quality is the ability of your electronic equipment to function properly.



Perfect quality power delivered at voltage, V, and frequency of 60 cycles per second (60 Hz).

SYMPTOMS OF POWER QUALITY DISTURBANCES

You may have power quality problems if you have experienced any of the following:

- Loss of computer data
- Random computer data errors
- Malfunctioning electronic equipment
- Flickering, dimming, or brightening of lights
- Increased service needs or decreased life of electronic equipment
- Overheated equipment
- Blown fuses
- Overheated or tripped breakers and relays

If you suspect that you have power quality-related problems, contact your electrician. You may also want to contact your local utility. They may have power quality experts who can help you determine the source of the problem. They also may sell or offer advice about buying equipment to resolve power quality disturbances. If your electrician or your local utility does not offer power quality services, contact a power quality consultant.

TYPES OF POWER QUALITY DISTURBANCES

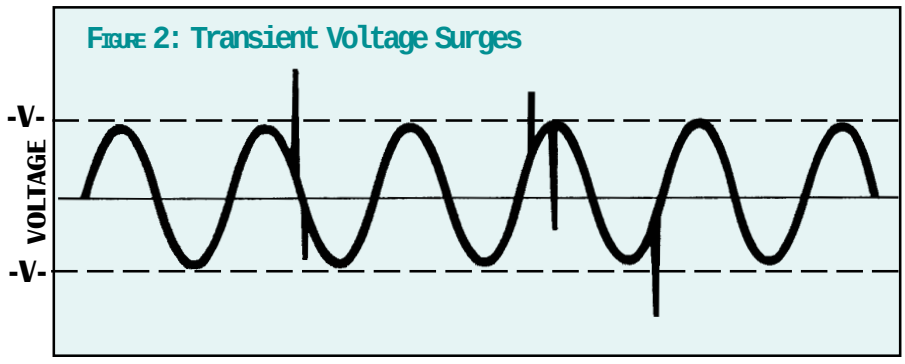
Power disturbances can take the following forms:

Transient voltage surges—also referred to as spikes and impulses, are very brief, sudden changes in normal voltage (see Figure 2). Impulses may exceed the normal voltage level by a factor of five or ten. Transient voltage impulses can:

- alter or erase computer data, produce computer errors, damage equipment, cause increased service requirements and decreased equipment life.
- be caused by lightning, switching on or off motors or lights, and when power returns after an outage.

Voltage dips and swells—(Figure 3) are short-term voltage fluctuations below (dips) or above (swells) normal voltage levels. Voltage swells usually have a lower magnitude and last much longer than transient voltage surges. Dips and swells are the most common form of power disturbances. They can:

- create flickering, dimming, or brightening lights and motor stalls.
- be caused by switching on or off large motors or welders, ground faults, or inadequate wire size.



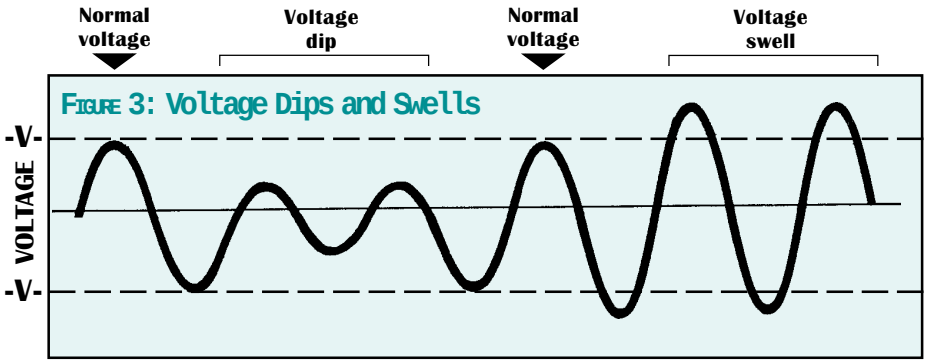


Figure 3: Voltage Dips and Swells

"Electric noise can give the normally smooth alterations of voltage a jagged or rough edge."

Momentary power interruptions—or blinks (Figure 4) are a complete loss of voltage for a short period of time. Momentary interruptions can:

- cause light flickering, lost computer data, flashing digital clocks, or reduced motor life.
- be caused by loose wire connections, lightning, tree limbs, ground faults, or utility switching.

Electric noise—(Figure 5) is a low-magnitude interference having a frequency interference that is a multiple of the normal frequency (60 cycles per second) AC voltage. Electric noise can give the normally smooth alterations of voltage a jagged or rough edge. Electric noise can:

- cause altered data, other electronic equipment errors, and fax, modem, or network problems.
- be caused by improper grounding of your electrical system. It can also be caused by loose connections, radio or TVs, variable frequency drives, unshielded cable, electronic equipment, lightning, fluorescent lights, or switching on and off electrical equipment. Noise can be transmitted from one wire to another or through the air.

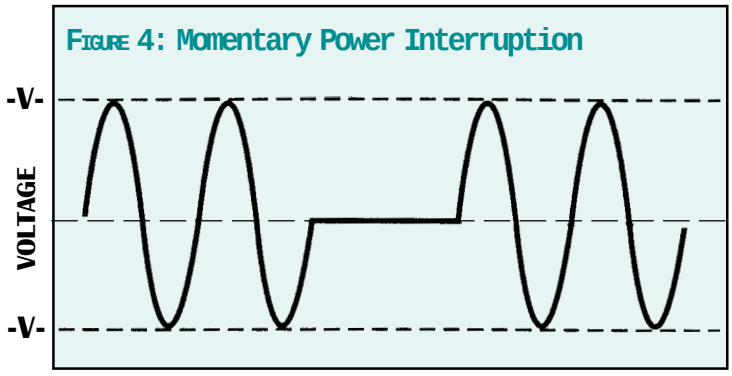


Figure 4: Momentary Power Interruption

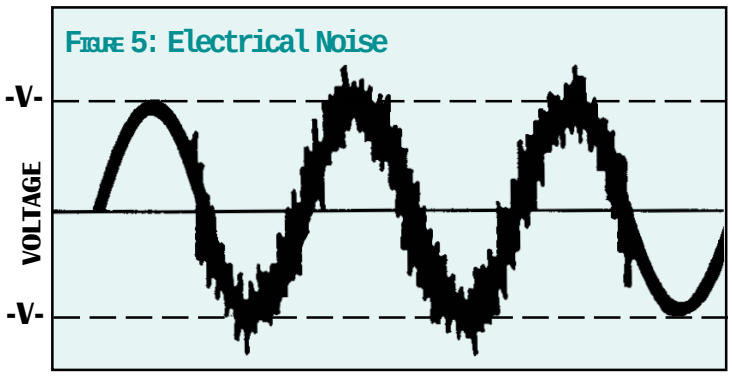


Figure 5: Electrical Noise

Harmonic distortion– (Figure 6) is an unwanted variation in the normal sinusoidal waveform that results from providing power to certain types of non-linear (electronic) loads. Harmonics are almost always caused by operation of equipment on the premises. They can:

- create reduced motor performance, reduced equipment life, blown fuses, tripped relays and circuit breakers, and overheated electrical equipment.
- be caused by variable frequency drives, computer power supplies, some UPS systems (see next section on Resolving Power Quality Issues), microwave ovens, battery chargers, and welding equipment.

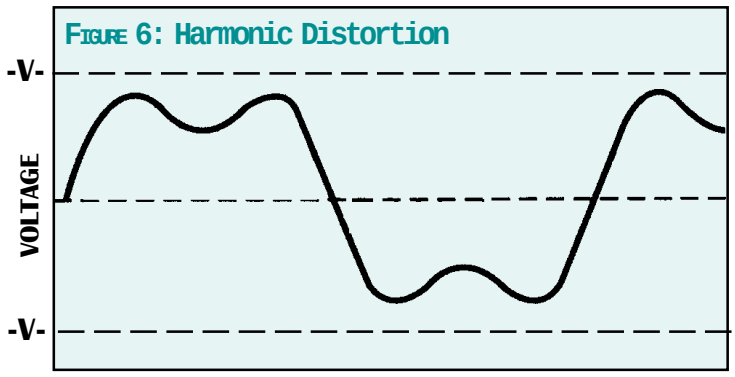


FIGURE 6: Harmonic Distortion

RESOLVING POWER QUALITY ISSUES

There are several things you can do to alleviate equipment problems associated with power quality. Improper wiring, inadequate grounding, and interactions with other electric loads at the facility are the most common causes of power quality disturbances. You should consider purchasing mitigation or power conditioning equipment only after you and a power quality expert have checked your facility's wiring and grounding system and have evaluated the types and locations of other loads that may cause power quality problems.

Mitigation and power conditioning equipment may not resolve power quality problems that arise from improper wiring or inadequate grounding. Therefore, it is essential to check the validity of your facility's wiring and grounding systems before making large expenditures on corrective or protective equipment.

Compliance with the National Electrical Code will not always ensure high quality power and fixing bad wiring will not necessarily solve all power quality issues. However, some simple wiring changes can make large improvements. Electricians should follow National Electrical Code, Article 250 for grounding. Tightening loose connections, adequately sizing conductors, providing proper grounding, and removing large motors from circuits containing electronics can all be effective solutions to solve power quality problems. Some other simple causes like static electricity may result in computer disturbances.

There is a wide variety of mitigation equipment available to solve different power quality disturbances. Not all mitigation equipment is suited for all problems. Following is a

"...it is essential to check the validity of your facility's wiring and grounding systems before making large expenditures on corrective or protective equipment."

summary of available mitigation techniques and equipment and a brief explanation of each.

- Separate culprit and victim loads to reduce potential damage from having disturbance-producing equipment and sensitive electronic equipment on the same circuit. This may require moving equipment to a different outlet, shifting loads on the panel, or having dedicated circuits to supply electricity to sensitive electronics. Dedicated circuits provide power to only one piece of equipment.
- Shielding can prevent airborne electrical noise from reaching and interfering with data lines. Buy good quality shielded cable for adequate protection.
- Transient voltage surge suppressors (TVSS) prevent voltage spikes from damaging your electronic equipment. TVSS work by diverting excess energy contained in voltage spikes away from the equipment and to the ground. The amount of voltage that is not diverted is dictated by the "clamping" level of the TVSS. Lightning arrestors used by utilities are designed to protect the electrical system from the enormous destructive potential of lightning and improve reliability. In order to accomplish this the clamping level is set very high. As a result, voltage that is still high enough to damage sensitive electronic equipment may still be present on customer wiring systems. Therefore, additional on-site lightning protection provided by the customer is required to ensure full lightning protection.

  TVSS Installation— A series of surge suppressors will protect electronics from transient voltage spikes. Install TVSS devices at the service entrance panel where electrical service enters the building, at all subpanels, and at outlets for all sensitive electronic equipment. Install surge suppressors as close as possible to the point of use. Ideally, install service entrance panel suppressors within six inches from the panel. Do not install a TVSS more than two feet from the service entrance panel. Place outlet surge suppressors as close as possible to the electronic equipment you are trying to protect.

  Buying a TVSS— Buy only surge suppressors that meet UL 1449 specifica-tions. The packaging should indicate if this specification has been met. Look for suppressors with metal housing and the proper voltage rating for the equipment it will serve. Inexpensive surge suppressors generally do not provide adequate protection for electronic equipment. Surge suppressors should be replaced approximately every five to ten years. Make sure there is an indicator light that confirms surge protection is functioning. It is very important to protect telephone lines (including fax and modem lines) from surges.
- Voltage regulators output relatively constant voltage over a wide range of input voltages. They protect against voltage dips and swells, and some will protect against momentary power loss. They will not protect against outages beyond their regulating capability. Voltage regulators do not suppress noise; they may, in certain cases, create electronic noise.

  Buying a voltage regulator— Things to look for when purchasing a voltage regulator include a voltage regulation of 4% or less for all load conditions, a rapid response time, greater than 90% efficiency, and a harmonic distortion of less than 3%.
- Isolation transformers reduce electrical noise from travelling through electric lines. They prevent noise produced by one piece of equipment from affecting the operation of another piece of equipment. Equipment served by an isolation transformer is isolated from the rest of the electrical system. Isolation transformers prevent common-mode (line-to-ground) electrical noise, but do not completely prevent normal mode (line-to-line) noise from reaching electrical equipment. They do not protect against dips, swells, transient voltage, or outages.
- Noise filters reduce noise by suppressing frequencies that are not the standard 60 cycles per second. Typically, they do not work as well as a wiring solution.

Harmonics filters are similar and are designed to mitigate measured harmonic disturbances. Harmonic filters must be custom-designed for the application.

- Standby Power Supply (SPS) systems use utility power until there is an outage and switch to an alternate power source such as a generator once an outage is detected. Because of the time required to switch to backup power, SPS systems may cause data loss. SPS systems may provide some surge protection.
- Uninterruptible Power Supply (UPS) systems contain batteries that store energy for use during power loss. They offer protection from power surges, outages, and voltage dips and swells. They provide power during an outage, typically for about 15 minutes and require no time to switch to battery power. A UPS constantly converts AC power to DC power to keep the battery charged. When the AC power is lost, the DC power of the battery is sent to an inverter. The inverter reproduces AC power to run a computer or another critical load. UPS systems prevent data loss during a power outage and provide more protection than SPS systems. However, UPS systems are more expensive than SPS systems.

CONCLUSION

As more agribusinesses and homeowners expand their use of microprocessor-based equipment, power quality will become of greater concern. Proper wiring and grounding practices will eliminate many power quality disturbances. However, some equipment can create power disturbances that need to identified and corrected. When correction is needed, there is a variety of equipment available to mitigate disturbances. Mitigation equipment can be expensive and should be used as a last resort after less complex solutions have been considered. A power quality expert should be consulted to help determine the source of a power quality disturbance and to advise in choosing the right solution for the situation.

"Mitigation equipment can be expensive and should be used as a last resort after less complex solutions have been considered."

RECORDING POTENTIAL POWER QUALITY PROBLEMS

If you experience a problem that may be power quality related, record it. You should be prepared to provide the following information when you talk to your electrician, local utility representative, or power quality consultant.

Potential Power Quality Problems

Date of occurrence: _____

Time of occurrence: _____

Description of Problem: _____

_____

_____

_____

_____

Equipment affected: _____

_____

Equipment in operation at time of problem: _____

_____

For recurring events

Frequency of occurrence: _____

Duration of problem: _____

When problem occurs (time of day, shift, when another activity is happening): _____

Weather: can you associate the incident with certain weather conditions? _____

Are there other signs of power related problems (tripped or overheated breakers, overheated transformers, burned insulation, arcing, fire)? Describe any changes made to the site recently (physical or electrical).

_____

_____

Have you added electrical equipment lately? _____

Do you use equipment intended to improve power quality (such as surge protectors)? _____

_____

References

Hall, David L., Straight Talk about Power Protection for Sensitive Electronic Equipment. 1995. Wisconsin Electric Power Company.

Hall, David L., An Introduction to Power Quality and Power Conditioning 1993. Wisconsin Electric Power Company.

Ryan, M.C., and D.H. Dederer, Power Quality Reference Guide. 1990. 2nd ed., Ontario Hydro.

Singletary, Bryan. 1997. Power Quality, Meeting Your Customer's Needs Through Power Conditioning. Presentation at the 35th Annual Conference of the Wisconsin Farm Electric Council, February 11-12, Stevens Point, WI.

Waller, Mark, PC Power Protection, 1989. Howard W. Sams & Company, Indianapolis.

Wisconsin Electric Power Company, Understanding Power Quality, 1993.

Mission Statement

This publication was developed by the Wisconsin Farm Electric Council.

The mission of the WFEC is to initiate, develop, support, and coordinate education, research, and communication programs on significant and emerging rural energy issues for the consumer, energy suppliers, and allied industries through cooperative efforts of council members.

Related Publications from the Wisconsin Farm Electric Council

Equipotential Planes for Stray Voltage Reduction
Farming Safely and Efficiently with Electricity
Planning electrical Systems for Dairy Expansions
Stray Voltage Detection, A Self-Help Guide

2/98