

Power Quality and the NEC Application Note - AN-18

In the United States, the safe use and installation of electricity is assured by compliance with the **National Electric Code**, otherwise known as the **NEC**. This document is used to design, install and inspect electrical wiring systems. When designing an electrical system to optimize power quality, an engineer must understand the requirements and the intentions of the NEC in order to assure both safety *and* power quality.

National Fire Protection Association

The NEC is a written and published by the National Fire Protection Association (NFPA) as standard NFPA-70. The NFPA is a private organization, consisting of representatives from engineering organizations, device manufacturers, and the electrical trades. NFPA standards are concerned predominantly with life-safety issues, especially those related to fire prevention and fire fighting.

NFPA standards are not federal laws, but are adopted by individual states and cities. They are periodically revised to accommodate changes in technology, materials, and industry practices. The NEC is on a 3 year revision cycle; the most recent revision is NFPA-70-1999.

The NEC is concerned with Safety

The intention of the NEC is *"...the practical safeguarding of persons and property from hazards arising from the use of electricity."* [NEC 90-1(a)] These hazards come in two main forms: **shock** caused by accidental contact of persons with live conductors, and **fire** caused by device overloading, misapplication, or malfunction.

The NEC is not concerned with the quality of electricity delivered to the facility equipment. Compliance with the NEC *"...will result in an installation that is essentially free from hazard but not necessarily efficient, convenient, or adequate for good service..."* [NEC 90-1(b)]

Designing "to Code"

The NEC is intended to be a minimum standard for safety. It is *"...not intended as a design specification nor an instruction manual for untrained persons."* [NEC 90-1(c)] Unfortunately, the NEC, or the "Code" has been used as a design specification for many years. If one were to ask an electrician to install a 100 Amp circuit, he will probably consult the NEC to select the wire size. What he is doing is determining the **minimum** wire size. But is it the correct wire size for the application?

How the NEC Undermines Power Quality

There are many instances where the installation of an electrical system "to Code" results in less than optimal power quality. The resulting system is safe and will marginally power the sensitive electronic equipment. However, the quality of the electrical power that such an installation delivers can be very poor.

Many NEC permitted practices have a negative impact on power quality:

- Reduced ground and neutral conductor sizes
- Sizing phase conductors for thermal performance, and not voltage drop
- Daisy chaining of neutral and ground conductors on multiple phase branch circuits
- Encouraging multiple, uncontrolled ground loops
- Use of conduit as the sole safety ground
- Use of conduit to chassis bonds as the sole ground path

All of these practices are valid from a safety standpoint. They may slightly reduce the overall system integrity or safety, but not to the point of increased hazard. However, some of these practices can *dramatically* reduce the power quality to sensitive equipment.

Electrical Designs for Power Quality

Engineers who design electrical systems to optimize power quality are required to comply with the NEC. Safety can never be sacrificed or reduced in order to obtain "clean" grounds or uninterruptible circuits. In the early days of power quality, many practices that were used to improve power problems created safety problems. As a result, electrical inspectors are very careful when inspecting electrical systems that incorporate special power quality techniques.



Some design techniques improve power quality with no impact on safety. These include:

- Using neutral and ground conductors the same size as the associated phase conductors
- Increasing conductor size to minimize voltage drop
- Grounding transformers and other sources via solid ground wire connections in addition to chassis grounds
- Using a dedicated circuit (one outlet per circuit) for sensitive loads

Power Quality Provisions in the NEC

While the NEC is not written to assure power quality, it does contain specific exceptions or provisions for techniques that add power quality without sacrificing safety. Some of these include:

- Provision for "Isolated" ground receptacles and fixed equipment [NEC 250-96(b) and 250-146(d)]
- Requiring larger grounds when conductors are oversized to minimize voltage drop [NEC 250-122(b)]

Specifying Power Quality

When specifying or designing the electrical supply for a sensitive electronic system, the manufacturer must take into account the electrical installation environment.

A simple electrical specification might be used:

Electrical:	208 VAC, 30 Amps
--------------------	-------------------------

If so, one is likely to get an installation that is rated for 208 VAC, 30 Amps, with minimum code requirements met. Power Quality is uncertain.

A better electrical specification might be:

Voltage:	208Y/120 VAC +/- 10% of nominal
Current:	30 Amps
Voltage Drop:	Not to exceed 2% at full load
Neutral:	Same size as Phase conductors
Ground:	Same size as Phase conductors
No other equipment to be powered from this branch circuit	

The facility electricians will ensure that the installation is safe, by compliance with the NEC. Compliance with the detailed manufacturer specifications will help ensure that power quality requirements are met.

Built - In NEC and Power Quality Compliance

In some cases, the need to use an existing electrical feed or competitive pressure makes asking for a special electrical installation difficult. Under these circumstances, manufacturers can ensure that equipment power quality is controlled with power conditioning devices.

A transformer based power conditioner, with low impedance, surge suppression, and filtering, can permit a sensitive system to operate properly from all types of installations, even those based on NEC minimum requirements.

***TEAL Electronics** power conditioners can help you satisfy NEC requirements without sacrificing power quality.*